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Last updated: 11/1/2018

Variables in climate, altitude, nutrient intake, photo period, surrounding farms and stress can lead to cannabis plants testing higher than the legal threshold established for industrial hemp and the estimates provided in this document.

HDOA makes NO warranty as to performance of any of the genetics it approves.

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Varietal information
Green Hawaii Genetics

This analysis provides information about a variety of hemp seeds grown by Green Hawaii Genetics for Hemp Project 17. All information reflects the average statistics over one full growing season. This project was limited to just one year and therefore cannot provide enough information for solid conclusions about strain genetics.

General information pertaining to all strains in this analysis:
ELEVATION

- Grow site was situated at 1,543 ft

WATERING

- Outdoors plants were watered a total of four times while establishing plants at an average of .5 - 1 gallon per plant
- Greenhouse plants were watered at an average of .5 - 1 gallon per plant every day until plants were established, then every other day on average (weather dependent)

PESTS

- Inch Worms (common name) - Lead to bud rot on larger buds in Greenhouse
- Broad mite - Occurred during the last month of the grow out

TREATMENTS

(All treatments adhere to organic growing practices)

- Removal of infested plants
- Sulphuric - Sprayed every week for 2 months
- Diplo (Organic worms insecticide) - Sprayed every week for 2 months

SOIL AMENDMENTS

(All amendments adhere to organic growing practices)

- Greenhouse and Outdoor: Local compost mixed with growing medium, calcium and chicken manure
- Greenhouse: Pear lite
- Outdoor: Mulch

TESTING

- Test results are an average of Greenhouse and Outdoor harvest

YIELD

- In order to red cross contamination, all plants were hand pollinated which led to lower seed yield

BEST PRACTICES

- Let the plants grow to full cycle for best seed yield
- Outdoor growing practices led to best seed yield results

Ka’u 18 X

Very mature strain, adapted to a variety of Hawai’ian climates. Stable industrial strain. Fiber not as vigorous as Yuma. Seeds are rich in color. Low CBD and THC levels. Airy flowers are large but not dense. Genetics not consistent, variables in plant structure.

Statistics			
Germination rate	33.75%		
Height	Greenhouse: 4-5.5’	Outdoor: 4-6’	
Test results	0.157% THC	2.7% CBD	
Plants harvested	Greenhouse 16	Outdoor 12	

SEEDLINGS

GREENHOUSE

OUTDOOR

KA’U 18XX
(MuttXOtto)

Strong healthy plant with a high seed yield. Resistant to mold, mildew and insects. Growing characteristics similar to the Otto 18. Mid range density growth habit.

Statistics			
Germination rate	75.25%		
Height	Greenhouse: 2.3’	Outdoor: 3’ - 5.25’	
Test results	0.072% THC	2.2% CBD	
Plants harvested	Greenhouse 27	Outdoor 27	

SEEDLINGS

GREENHOUSE

OUTDOOR

Kau 18 XXX
(Harli x Otto)

Good greenhouse strain. Dense, bushy growth habit. Exceptional outdoor strain. Easily thrived in the Hawai'ian climate. Susceptible to wind damage. Some mildew during flowering. Heavy flowering habit producing large, compact flowers. Has potential to be a consistent high CBD strain, making it a viable seed for the Hawai'ian hemp industry.

Statistics			
Germination rate	30.75%		
Height	Greenhouse: 4-6'	Outdoor: 7-10"	
Test results	0.24% THC	3.9% CBD	
Plants harvested	Greenhouse 25	Outdoor 14	

SEEDLINGS

GREENHOUSE

OUTDOOR

Otto 18

Strain produced small seeds when compared to Ka'u18 XXX and Ka'u 18 XX. Plants had a thin growing habit producing small flowers and seeds. Otto 18 was cross pollinated four times with its own genetics, making it well adapted to the Hawai'ian climate. Seed germination was a bit low due to early harvest.

Statistics			
Germination rate	30%		
Height	Greenhouse: 4-5.5'	Outdoor: 4-6.'	
Test results	0.21% THC	3.3% CBD	
Plants harvested	Greenhouse 26	Outdoor 21	

SEEDLINGS

GREENHOUSE

OUTDOOR

Yuma

Most rapid growing strain of all varieties tested. Yuma plant growth was 3x faster than other strains. Potential to be a massive fiber material strain. Produced flower after 8 months. Not recommended as a greenhouse strain. At full maturity stocks were 3-4” in diameter. Susceptible to wind damage, multiple plants knocked down during hurricane Lane. Highly adapted to the tropical climate.

Statistics			
Germination rate	90%+		
Height	Greenhouse: 4-6’	Outdoor: 7-15’’	
Cannabinoid levels:	THC: 0.25-0.5%	CBD: 0.7%	

SEEDLINGS

GREENHOUSE

OUTDOOR

Second Six-Month Report: A Focus on Agronomic Results
UH-HDOA Hemp Seed Development Contract
August 9, 2018

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I. INTRODUCTION

This report covers the second six month period of the University of Hawai`i-Manoa's 2017-2018 hemp seed development contract with the Hawai`i Department of Agriculture. It focuses on the first seven months of crop growth, with observations and data from the planting of three plots of the Yuma cultivar (*Cannibis sativ*a, Zhong Long Hemp Farm, Seed Lot 20171010).

Initial planting for this phase of the study occurred on January 16, 2018, with additional plantings on May 8 and June 5, 2018. Plot 1's seed was harvested in early May and plants began to senesce in late May; some plants are still alive. Plots 2 and 3 are currently at different points of the flower development stage. Plot 3 was planted using seed harvested from Plot 1.

II. GENERAL INFORMATION

There are many guidelines and resources available from other hemp producing areas, such as the mainland USA, Canada, Europe and Asia (*see links to resources at end of report*). Adapting and modifying this information in response to Hawaii's climate has been a constant part of our work, and will continue to be so for farmers involved in the early years of Hawaii's nascent hemp industry.

Hemp performs optimally with 12+ hours of daylight, therefore crops grown between March and October will likely perform best. Microclimates within Hawai`i may also impact hemp growth. Our 1st plot planted in January was grown during a shorter photoperiod, with a relatively small seed yield and moderate fiber/vegetation. Plots 2 and 3 are developing at a different rate than Plot 1. We have not had the opportunity to test the performance of a fall planting.

Basic Requirements:

- Thorough tilling of the soil is recommended;
- Hemp requires good drainage and sufficient nitrogen;
- Limited irrigation is needed after germination;
- Minimal, preventative pest control may be required, particular during sprouting and maturing seed stages; and
- Minimal weeding may be needed during the first few weeks, until hemp has enough vegetative growth to naturally suppress weeds for the duration of its lifecycle.

Challenges:

- Significant variability is evidenced by the Yuma cultivar, particularly in its germination rates (by seed size), growth rates and seed development;
- Selective breeding is likely needed to create a more uniform crop, or homogeneous seeds need to be imported;

- More hemp varieties need to be tested in Hawaii;
- It would be an advantage to grow a variety that will be harvested during the dry season (June – August), particularly for seed production; and
- Equipment and infrastructure may need to be imported or modified for planting, harvesting, processing, and manufacturing.

III. METHODOLOGY

Our project's available resources called for hand planting and harvesting, therefore plots were kept small to make this work feasible. Those growing on larger acreage and using machinery for planting, harvesting, and processing may want to take a different approach to plant and row spacing.

- Standard agricultural practices were used for soil preparation and field germination of seeds;
- Plant and row spacing was varied in the three plots to see how yields might be affected;
- In each plot, sections containing 3 to 4 rows were separated by a one-meter space (covered with weed cloth or mulch), in order to better facilitate data collection and hand harvesting;
- Seeds were planted at a minimum depth of 2.5 cm (1 in);
- The plots were kept moist for germination and supplemented during the first two weeks with moderate drip irrigation (flow rate 0.67 gallons/minute or 50.8 gallons/minute/acre, for one hour) when no rainfall occurred (up to 10 mm, applied 2-3x/week). Subsequently, the plots were irrigated 1-2x/week, depending on weather;
- Plots were weeded during the first few weeks to control morning glory vine; and
- Nitrogen was substantially amended in Plots 2 and 3.

Soil Amendment:

As the 2015-16 crops seemed to perform equally with or without added nutrients, soil amendment was not applied on Plot 1 prior to planting. Nitrogen was applied via foliar fish emulsion periodically throughout growth cycle.

Since Plot 1's seed yield was minimal and soil in Plots 2 and 3 tested deficient in nitrogen prior to planting, these latter plots were amended at the time of planting and post-planting with slow release, granular organic fertilizer (Sustane 8-2-4) at a rate of 100 pounds per acre (total, over the course of crop lifecycle). Additional foliar application of fish emulsion will be applied as needed.

Seed Placement:

Due to a notable difference in the size of seeds, the seeds of three identified sizes were planted separately in a small portion of Plot 1 in order to assess any marked differences in growth characteristics. However, each seed size produced plants that varied in gender, height, stem circumference, and timing/rate of seed development. The remainder of Plot 1 was planted with the mixed seed, and exhibited the same variation in characteristics as the seeds of three identified sizes. Such planting comparison was repeated in Plot 2 with the same results. Therefore, it appears that seed size cannot be used to predict and select certain growth characteristics.

Seed and row spacing was varied by plot to observe any difference in branching and seed development, while still maintaining weed suppression benefits. Plot 1: 1-2 seeds every 25 cm (10 in); Plot 2: 2-3 seeds every 40 cm (16 in); and Plot 3: 2-3 seeds every 30 cm (12 in).

Additional Notes on Plot 1 (January Planting):

Plot 1 was intended as a negative control, to see how Yuma performs during a short photoperiod (less than 11.5 hours of daylight) and rainy season. No supplemental lighting was used. Such control is important for Hawaii's hemp program. Heavy and consistent rain occurred from February through

seed harvest in May, therefore little irrigation was needed. The plants generally withstood heavy rainfall, flash flooding, and strong winds.

Plot 1 was left intact after seed harvest to see whether the plants might re-flower and re-seed after pruning or generate more sprouts from fallen seed, and how long the plants might live (for potential usage in erosion control, windbreak, animal "fencing"/deterrent, animal bedding, biomass/fiber applications, etc.). No new male flowers, re-seeding or new sprouts have been observed. While many plants have died, some are still alive (but ailing). Plants have reached heights of up to 4.3 m with stem diameters (base of stem at soil surface) ranging from 2 cm to 12 cm.

IV. OBSERVATIONS *For quick reference, please see the growth data table at the end of this report.*

Germination:

Our seed germination test prior to planting showed 90% germination rate for smallest seeds, 60% for medium and 30% for large seeds; this was also evidenced in field planting by separate seed size in Plots 1 and 2. Overall field germination rate for areas planted with mixed seed sizes: Plot 1: 80-85%, Plot 2: 80-95%, and Plot 3: 80-85%.

Growth:

- Most sprouts appeared between Day 3 to 5 in all three plots; additional sprouts appeared in Plot 3 through Day 8;
- Starting at Week 4, fast growth (height and vegetation) occurs;
- The Yuma seed producer indicated that flowering should occur at 60 days (8.5 weeks), with maturation at 120-180 days (17 to 25.5 weeks); our January-planted crop began flowering at 4 weeks, while Plot 2 (May) began flowering at 12 weeks and Plot 3 (June) by 9 weeks;
- Seed development began in Plot 1 at Week 8 and Plot 2 at Week 13; Plot 3 has not developed seed yet (at Week 9); and
- Overwatering may result in less healthy root development.

For sections in which the three sizes of seed were separately planted:

- The large and medium size seeds produced larger, rounder 1st pair of leaves (0.5 in long) compared to the smallest seed size (0.25 in long);
- The large seeds were the first to grow 4th pair of leaves (Day 9) and their stems appeared thicker;
- From then on, there was wide variation in plant height and stem thickness within each separately planted area; and
- No differentiation was noted in seed yields from the three different seed sizes planted.

Flowering in Plot 1 (planted in January) occurred at a similar age and height as a different Chinese-derived subtropical seed cultivar planted in April 2016 at the same location:

- 2016 subtropical fiber cultivar flowered at Week 8, median height 90 cm;
- 2016 subtropical seed cultivar flowered at Week 3.5, median height 18 cm; and
- 2018 Yuma cultivar:
  Plot 1 (January planting) flowered at Week 4, median height 13 cm.
  Plot 2 (May planting) flowered at Week 11, median height 2.15 m.
  Plot 3 (June planting) flowered at Weeks 7 (female) to 9 (male), with median heights of 80 cm to 1.2 m over the course of these two weeks.

At the time of this report, Plots 2 and 3 are still growing and continue to develop more flowers.

Variability:

- Plants vary greatly in height, stem circumference, and timing/rate of seed development;
- Plot 1 female plants developed seeds at three different rates: the first two groups approximately two weeks apart; the third group never developed seed; and
- In Plot 3 some plants developed multiple branches early on, while others have atypical leaf shapes (larger and rounded with wavy edges).

V. PESTS

Weeds:

Certain weeds that were problematic during the University's 2015-16 hemp research project, particularly the morning glory vine and large grasses, were systematically removed (when young) by hand and hoe as a preventative measure during the first few weeks. This was successful; once the hemp reached Week 4 and started producing more vegetation, it successfully suppressed any remaining small weeds.

Insects, etc.:

Pests that impact plant growth and yields have been observed during all three crops of this 2018 contract. Comparatively, our 2015-2016 research project did not suffer from pests. Pest control measures have included hand removal, slug/snail bait traps (iron phosphate pellets), Diatomaceous Earth (slugs, snails, ants), Terro liquid ant traps (borax), reflective tape (birds), and soapy water or Neem applications (other insects and fungi). Various types of mint and basil were planted around the perimeter of Plots 2 and 3 as potential pest deterrent. Thus far, the impact of this technique is indeterminate.

Links to hemp pest identification and treatment guides (for temperate climates) are included in the Resources section at the end of this report. Keep in mind that conventional pesticides are not currently approved for use on hemp in the United States; organic controls may be used.

ANTS. Black ants were observed in Plot 1. Black and red ants have been observed in Plots 2 and 3. Ants may have been responsible for eating some young sprouts, and recently red ants were infesting the roots of two, fallen 9 week-old plants in Plot 3. Borax and Diatomaceous Earth treatments are effective.

BIRDS. Young sprouts were occasionally uprooted by birds during the first week, when no bird deterrent was in place. When bird deterrents (fluttering bright colored tape or reflective tape) were in place through Week 2-3, no sprouts were lost to birds. Three bird nests were observed in Plot 1 beginning at Week 12 (Japanese White Eye and Cardinal). Some minimal seed loss (of earliest maturing seed) occurred from various additional birds. We plan to reinstall reflective tape prior to seed maturation to deter mature seed losses to birds in Plots 2 and 3.

SLUGS AND SNAILS. Young plants were susceptible during the first 3 weeks. In Plot 1, 20% of sprouts were lost to these pests during Weeks 1-2, with lesser but continued loss through Week 3. These pests did not impact older plants until seed matured, when large African snails were observed 4 to 6 feet up the plant eating mature seed. Iron phosphate pellets were applied with great success for Plot 1. In Plots 2 and 3, wild pigs were eating the iron phosphate so we switched to using Diatomaceous Earth, which has been equally successful and also helps control ant populations.

SPITTLEBUG. This insect sucks moisture from plants; in general, in other climates, it is not known for killing plants but can decrease yields. Its young (nymphs) are encased in a foamy, saliva-like

substance. Left untreated, they can rapidly multiply. It has been observed on both male and female plants.

- Plot 1: spittlebug appeared at Week 10 (late March) after seeds began to form;
- Plot 2: it appeared at Week 10 (mid July) prior to flower or seed formation; and
- Plot 3: it appeared at Week 8 (late July) prior to flower or seed formation.

Because the spittlebug is clustering around our hemp flowers and seeds, we are currently keeping spittlebug presence minimized in Plots 2 and 3. We are removing spittle and the underlying nymph clusters using a jet-spray of soapy water and/or neem followed by overall misting, especially of perimeter plants. Plain water can also be used to dislodge nymphs in minor occurrences.

Until the definitive impact on seed yield is identified, we recommend seed farmers (especially on small acreage) start treating upon the first occurrence to prevent this pest from multiplying to a point where it is challenging to control. Look for a powdery white film on stalks and other plant parts, as well as the presence of small, rounded, black beetles (adult), as these are the precursors to heavy nymph and spittle formation. Farmers growing for fiber may opt to leave spittlebugs untreated, as thus far it does not seem to impact the stalk growth. However, we have not assessed the impacts of spittlebug on fiber quality.

STINK BUG (GREEN). This insect also extracts plant fluids and has been known to impact seed production on the mainland. For Plot 1, they were first observed at Week 14 (late April) when seeds were midway through maturing. They were removed by hand whenever they were observed (they are hard to spot!). We have not yet seen them in Plots 2 and 3.

OTHER:
In Plot 1, possible thrips were noted at Week 2, minimal presence of leaf miners and grasshoppers at Week 3, and white flies at Week 4. Their presence did not negatively impact the growth or health of the plants. Application of soapy water spray and neem to treat these pests was successful. Potential virus and fungus are apparent in Plot 2, yet to be identified. Aphids were mitigated by ladybugs.

In addition to ladybugs, other beneficial insects observed include bees, praying mantis, wasps, flies, and spiders.

Pigs and chickens have not proven to be problematic. Wild pigs roamed through both 2016 and 2018 projects, without disturbing plants at any stage (with the exception of eating the slug bait!). Recently a flock of chickens were observed foraging for insects in Plot 2.

VI. YIELDS

Plots 2 and 3 (May and June plantings) should have higher yields of both seed and fiber than Plot 1 (January planting) due to a longer photoperiod, increased pest control, and current growth rates. Selective breeding, photoperiod, plant spacing, and experimentation with nutrient application may increase yields in future crops. Microclimates may also have an impact on yield rates. Yields from Plot 1 should be considered anecdotal and not indicative of the full potential of the Yuma cultivar.

Seed:

Industry standard seed yields (in general, for all hemp seed cultivars), based on 1 crop per year. Canada averages 600 - 800 lbs or 0.3 - 0.4 tons per acre. Others claim between 100 – 1,200 lbs (0.05 - 0.6 tons) or 1,200 – 4,800 lbs (0.6 - 2.4 tons) per acre, depending on the source.

In our January planting, we experienced a 60% survival rate due to pest impacts on sprouts (slug, snail, bird and possibly ants). Once the plants were 2 to 3 weeks old, these pests did not appear to cause damage. Some mature plants were affected by pest damage (other insects, snails, and birds).

50% of the surviving crop was male; 25% of the surviving crop (or 15% of the total planted area) produced seed at a rate of 130 lbs or 0.07 ton/acre. At two crops per year, this rate would yield 260 lbs or 0.13 ton/acre.

It must be reiterated that this planting occurred during a shorter than optimal photoperiod followed by two months of heavy rain and flooding during seed production stage. Combined with unanticipated pest impact, these variables may have significantly lowered the seed yield potential of this particular Yuma crop. If in future crops the plant survival rate is improved and feminization is optimized, then seed yields for Yuma should significantly increase.

We anticipate a higher seed yield rate from the May and June plantings, due to planting during a more optimal photoperiod, the application of preventative and mitigating pest control measures, and the crops' current growth performance.

Fiber:

Yuma's potential fiber yield appears promising. Plot 1 reached a height of 3.3 meters (11 feet) before senescing. Plot 2 has already surpassed this, reaching 5 meters (16.4 feet) by Week 13. Plot 3 will likely also be taller with more vegetation, having reached 2.5 meters at Week 9. Plots 2 and 3 are still growing and have not yet reached full height/vegetation growth.

VII. PHOTOS are available if needed, and may be provided in a later update.

VIII. RESOURCES

www.naihc.org National Advisory in Hemp & CBD, includes *1913 USDA hemp farming guide:* www.naihc.org/hemp/yearbook-of-the-united-states-department-of-agriculture-1913

www.purduehemp.org Industrial Hemp Education and Producer Guidance (Purdue University, Indiana)

www.purduehemp.org/hemp-production Nutrient and Growth Guide

www.dl.sciencesocieties.org/publications/cftm/pdfs/1/1/cftm2015.0159 Nutrient/Rates Study (Canada)

www.hempinsects.agsci.colostate.edu/hemp-insects-text Insect Guide (Colorado State University)

Hemp Diseases and Pests - Management and Biological Control by John Michael McPartland, Robert Connell Clarke, David Paul Watson (2000).

www.votehemp.com Hemp Farming Legislation, Information and Advocacy

www.votehemp.com/PDF/hemp_tech_manual-eng.pdf Canadian THC sampling guideline

www.hemptrade.ca Canadian Hemp Trade Alliance (International Industry News and Resources)

IV. YUMA GROWTH DATA TABLE *See next page.*

YUMA growth data (as of 8/7/2018)	**PLOT 1 (1st gen. seed)**	**PLOT 2 (1st gen. seed)**	**PLOT 3 (2nd gen. seed)**
Date Planted	**January 16, 2018**	**May 8, 2018**	**June 5, 2018**
Date sprouts emerge	Day 3 to 5	Day 2 to 5	Day 2 to 8
Germination rate (field planted)	80 to 85% overall (ranged from 30% to 90% depending on seed size)	80-95%	80 to 85% overall (ranged from 35% to 95% depending on seed batch)
Height at 4 weeks	4 cm to 23 cm (median 13 cm)	5 cm to 40 cm (median 20 cm)	1 cm to 33 cm (median 12 cm)
Height at 6 weeks	18 cm to 1.27 m (median 70 cm)	10 cm – 1.48 m (median 75 cm)	1 cm to 1.1 m (median 40 cm)
Height at 8 weeks	7 cm to 1.94 m (median 1.2 m)	7 cm – 2.45 m (median 1.2 m)	6 cm to 2.07 m (median 1.1 m)
Height at 12 weeks	90 cm to 2.45 m (median 1.7 m)	33 cm to **4.6 m** (median 2.3 m)	N/A
Height at 16 weeks	1.05 m to 3.25 m (median 2.3 m)	N/A	N/A
Final Height	**Week 28:** 1.69 m to **4.3 m** (median 3.3 m)	N/A	N/A
Date of 1st flowers developing	**Week 4** (Feb. 12, 2018): male and female	**Week 11** (July 24, 2018): male buds, some possible female	**Weeks 7-8**: possible females ID'd **Week 9** (Aug. 7, 2018): 1st male buds
Date 1st seeds appear	Week 8 (March 14, 2018)	N/A	N/A
Date of THC testing	Week 14 (April 24, 2018)	N/A	N/A
Date of seed harvest	Weeks 15 to 17 (May 1-14, 2018)	N/A (mid-late Sept. anticipated)	N/A (October anticipated)
Date senesced	+/- Week 18 (May 24, 2018); *Week 29 (Aug. 7, 2018): Many dead; some still alive but ailing	N/A	N/A

Puma

- **Origin:** China, Zhong Long Hemp Farm (same seller as Yuma).
    - Tropical varietal. Has not been tested in Hawaii yet.
    - Recommended for outdoor growth.
- **Growth characteristics:**
    - Quick vertical growth.
    - Height: 10-15 feet
    - Time of Flowering: 165-170 days (Male) 180-200 days (Female, depending on the climate/photo period)
- **Cannabinoid levels:**
    - THC: -0.15-0.3%
    - CBD: 2-4%
- **Germination Rate:** TBD