Virginia Department of Agriculture and Consumer Services

ANNUAL REPORT

ON THE

STATUS AND PROGRESS

OF THE

INDUSTRIAL HEMP RESEARCH PROGRAM

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Commissioner

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Annual Report on the Status and Progress of the Industrial Hemp Research Program

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Executive Summary
The 2015 Session of the Virginia General Assembly enacted the Industrial Hemp Law (Law) (Va. Code § 3.2-4112 *et seq.*), which authorizes the Virginia Department of Agriculture and Consumer Services (VDACS) to establish and oversee an industrial hemp research program that will be directly managed by public institutions of higher education. 2016 marked the first year that the three public universities with VDACS-approved industrial hemp research programs grew industrial hemp in Virginia. These universities planted a total of approximately 37 acres in industrial hemp. To facilitate the universities' research projects, VDACS imported 16 varieties of industrial hemp and issued Industrial Hemp Grower's licenses to 29 individuals.

BACKGROUND AND OVERVIEW

The U.S. Congress, through Section 7606 of the Agricultural Act of 2014, allowed state departments of agriculture to grow industrial hemp for research purposes, under certain conditions. The 2015 Session of the Virginia General Assembly enacted the Industrial Hemp Law (Law)[1], which authorizes the Virginia Department of Agriculture and Consumer Services (VDACS) to establish and oversee an industrial hemp research program that will be directly managed by public institutions of higher education. In August 2015, VDACS entered into a memorandum of understanding with James Madison University (JMU), Virginia State University (VSU), and Virginia Polytechnic Institute and State University (Virginia Tech) (collectively "research universities") to conduct industrial hemp research.

In 2016, the research universities planted a total of approximately 37 acres in industrial hemp. To facilitate the universities' research projects, VDACS imported 16 varieties of industrial hemp and issued Industrial Hemp Grower's licenses to 29 individuals.

CONTROLLED SUBSTANCE IMPORTER REGISTRATION

In order for VDACS to import industrial hemp seed, the agency must obtain from the U.S. Drug Enforcement Administration (DEA) (i) an importer registration under the federal Controlled Substance Act and (ii) a separate permit for each shipment that the agency imports.

On September 14, 2015, VDACS received its initial Controlled Substance Importer Registration from DEA. On June 21, 2016, DEA conducted an on-site inspection of VDACS's Seed Laboratory, where VDACS stores its industrial hemp seed. DEA subsequently renewed VDACS's Controlled Substance Importer Registration on July 26, 2016.

HEMP SEED FOR PLANTING

In January 2016, VDACS contracted with a consultant who assisted the agency in identifying available varieties of industrial hemp seed for planting, coordinating the purchase of the industrial hemp seed varieties selected by the principal investigator of each research program, and preparing VDACS's applications for controlled substance import permits.

The consultant also facilitated an unexpected negotiation regarding the material transfer agreements (MTA) that four seed companies requested VDACS and the research universities sign. Three of the four MTAs contained clauses that restricted the publication of research results related to their respective seed varieties and defined the governing law for the MTA as a body of law other than that of the Commonwealth of Virginia. As state agencies or institutions, VDACS and the universities are not able to sign MTAs with these types of clauses and, as such, VDACS did not purchase seed from three of the companies. VDACS and the universities did find an agreement with the fourth company and were able to sign the company's MTA.

[1] Va. Code § 3.2-4112 *et seq.*

VDACS imported 16 varieties of industrial hemp seed, which originated in five different countries. VDACS intended to import a quantity of the varieties selected by VSU and Virginia Tech to provide planting seed for two growing seasons. As the seed suppliers often required VDACS to place a minimum order of 55 pounds per variety, VDACS currently has approximately 400 pounds of seed that are not already obligated to VSU or Virginia Tech and are available for use in future research.

Table 1. Country of origin of the industrial hemp seed varieties imported by VDACS.

Canada	Poland	France	Italy	Ukraine
Canda	Biedloreski	Fedora 17	Campana Eletta	Glesia
Delores	Tygra	Felina 32	Carmagnola	Gliana
Joey	Wojko	Futura 75	Fibranova	USO31
				Zolotonosha 15

At this time, given the resources and significant amount of staff time required to import seed, VDACS does not plan to import additional planting seed for future growing seasons. A research university may apply for a DEA controlled substance registration in order to import seed if the university wants to use a variety that VDACS does not already have or an amount of a variety that is greater than that which VDACS currently possesses.

Although VDACS began the process to identify and procure industrial hemp seed in late 2015, the agency did not receive the majority of the seed it ordered until June 2016. The unexpected delays were due to a variety of reasons, including delays in the issuance of necessary documentation in the shipments' countries of origin, damage to a shipment that required VDACS to reorder two varieties of seed, and the loss of required import documentation once certain shipments were in transit, which delayed those shipments' release by U.S. Customs and Border Protection. These delays negatively impacted the universities' research plans. Most notably, Virginia Tech and VSU postposed their planned planting timing date study until the 2017 growing season.

INDUSTRIAL HEMP GROWER'S LICENSE

The Law requires that, before growing industrial hemp as part of the industrial hemp research program, an individual must (i) have an agreement with a public institution of higher education that documents that the individual will be a participant in that institution's industrial hemp research program and (ii) obtain a grower's license from VDACS.[2] The Law also requires that a state and national fingerprint-based criminal history background check be a component of the application process for this license.[3] VDACS implemented the industrial hemp grower licensing program in September 2015 and has issued 29 licenses as of September 30, 2016.

[2] Va. Code § 3.2-4115(B)
[3] Va. Code § 3.2-4115(C)

Table 2. Number of licensed industrial hemp growers.

University conducting hemp research	Number of licensed industrial hemp growers participating in the hemp research
James Madison University	17
Virginia State University	3
Virginia Tech	9

VDACS absorbed the fee charged by the Virginia Department of State Police to complete a background check for each of the individuals currently licensed. In October 2016, VDACS modified the licensing program to include the collection of an annual licensing and background check fee in accordance with Va. Code § 3.2-4115. The licensing fee is now $20, and the background check fee is $37.

UNIVERSITIES CONDUCTING RESEARCH

In August 2015, VDACS entered into a memorandum of understanding (MOU) with JMU, VSU, and Virginia Tech to conduct industrial hemp research. In June 2016, VDACS renewed each university's MOU for a second year.

While there is no specific industrial hemp funding available through VDACS for those public institutions of higher education that enter into these MOUs, VDACS was able to provide a total of $35,000 in fiscal year 2016 for industrial hemp research ($17,500 to both of the land grant universities, VSU and Virginia Tech). This funding was part of a larger annual appropriation of $75,000 that VDACS receives for research, development, and applied commercialization of specialty crops.

VDACS distributed a portion of the industrial hemp seed it imported to VSU and Virginia Tech, both of which grew industrial hemp on university-owned or university-managed property. VDACS also transferred the portion of the seed it imported on JMU's behalf to JMU. As JMU used private farms to grow industrial hemp, following guidance from DEA, JMU obtained its own controlled substance registration in order to be able to receive seed from VDACS. The universities planted a total of approximately 37 acres in industrial hemp by late June 2016. Industrial hemp was grown in Albemarle, Chesterfield, Montgomery, Nottoway, Orange, and Rockingham counties. As the universities' proposed research extends over at least two years and the MOUs establish the option to renew the research agreement annually for up to five years, at the time of this report, none of the universities have definitive findings to report.

Each university submitted a progress report on its research to VDACS. A summary of each report is provided below, and the reports are included in the appendices of this report.

<u>James Madison University</u>

JMU is researching how effectively industrial hemp grows in Virginia's Ridge and Valley region and is testing whether industrial hemp seed can be planted and harvested with conventional agricultural equipment. JMU is also investigating the use of industrial hemp seed oil in the production of biofuels.

JMU partnered with two private farmers to grow industrial hemp in Albemarle and Rockingham counties. Both farmers grew the same single cultivar of an oil seed hemp variety. In Albemarle, approximately 10 acres were planted in this industrial hemp variety on June 22, 2016. Weed pressure was significant in the hemp field in Albemarle, and weeds eventually overtopped the hemp. In Rockingham, approximately 10 acres were planted in industrial hemp on June 27, 2016. Weeds were present along the border of the hemp field in Rockingham but rarely present in the field under the hemp canopy. JMU surmises that a higher planting rate and quick canopy closure is important to establishing a quality hemp stand. JMU had not completed its hemp harvest at the time of its progress report. However, JMU has determined that hemp planting should occur earlier in the season than late June and that it should increase the seeding rates it used in 2016.

See Appendix A for the complete report submitted by Dr. Michael Renfroe, the principal investigator for JMU's hemp research.

Virginia State University

VSU is researching and analyzing required soils, growing conditions, and harvest methods related to various varieties of industrial hemp; conducting industrial hemp seed research; and studying the use of industrial hemp in new energy technologies.

VSU is conducting its research at its Randolph Farm in Chesterfield County. VSU planted one grain-type hemp variety and one fiber-type hemp variety on May 27, 2016, for its nitrogen fertility study. VSU also planted four grain-type varieties on June 7, 2016, for its variety trial. VSU reports that bird infestation was a major problem and that, despite late planting, initial assessment shows that the varieties planted can grow under Virginia conditions.

See Appendix B for the complete report submitted by Dr. Maru Kering, the principal investigator for VSU's hemp research.

Virginia Polytechnic Institute and State University

Virginia Tech is conducting agronomic trials to identify industrial hemp varieties that are well-suited to the soils and climate of Virginia and to compare yield responses to various agronomic treatments. Virginia Tech is conducting its research at the following Virginia Tech-owned or managed properties: Kentland Farm in Montgomery County, the Northern Piedmont Center in Orange County, and the Southern Piedmont Agricultural Research and Extension Center in Nottoway County. Virginia Tech's initial results indicate that, despite late planting dates, hemp can be productive in Virginia, but it is sensitive to factors such as soil type and available moisture.

Virginia Tech planted several varieties of industrial hemp at both Kentland Farm and the Northern Piedmont Center and tested varietal differences under both grain and fiber management. The Kentland Farm plots were established on July 7, 2016, and the Northern Piedmont Center plots were established on June 30, 2016. Fibers from both locations were field retted in Blacksburg and, once the samples are processed into bast fibers, Virginia Tech will examine the fiber properties. At the time of report submission, grain samples had been threshed from the stalks, but not yet dehulled. Virginia Tech surmises that the late planting dates negatively impacted grain yield.

Virginia Tech also planted a single variety of industrial hemp at the Southern Piedmont Agricultural Research and Extension Center on June 20, 2016, to determine the effects of fertility management and establishment practices on both grain and fiber production. Virginia Tech's comparison of its conventional tillage trial and no-tillage trial indicate that improved water retention and less evaporation from the no-tillage trial benefited plant growth throughout the season.

Virginia Tech's entomologist was surprised by the number of insect species that fed on the industrial hemp growing at Kentland Farm, and Virginia Tech intends to conduct follow-up on this occurrence. Virginia Tech also experienced a high level of predation on the grain of the hemp plants by several bird species and is considering exploring hemp as an opportunity to support the game bird industry and to bolster quail populations.

See Appendix C for the complete report submitted by Dr. John Fike, the principal investigator for Virginia Tech's hemp research, with collaboration from Dr. Carol Wilkinson.

Tetrahydrocannabinol (THC) Testing

The Commissioner of Agriculture and Consumer Services is responsible for providing random testing of industrial hemp for compliance with THC levels.[4] At VDACS's request, the Department of General Services' Division of Consolidated Laboratory Services (DCLS) identified and validated a test method it will use to determine the THC content of industrial hemp samples collected by VDACS inspectors.

VDACS collected samples of each industrial hemp variety grown at each of the universities' production fields and submitted these samples to DCLS for testing. Test results are pending for all of the samples.

Beginning January 1, 2017, VDACS will collect a THC testing fee per sample taken from each public institution of higher education participating in the industrial hemp research program. This fee will include any costs set by DCLS and may include additional administrative fees as established by the Commissioner. The fee is approximately $200 per sample. VDACS anticipates taking no more than one sample per industrial hemp seed variety from each production field.

2016 Request for Proposals

[4] Va. Code § 3.2-4115(K)

On May 25, 2016, VDACS issued a second Request for Proposals (RFP), RFP number 301-16-124, seeking public institutions of higher education interested in conducting industrial hemp research. The RFP asked that the proposals indicate the institution's intended area of research, experiment procedures, and plot location and size and that the proposals indicate whether the institution intends to obtain industrial hemp seed from VDACS or via its own DEA controlled substance registration.

VDACS received a proposal from the University of Virginia (UVA). Upon the recommendation of the agency's RFP evaluation committee, VDACS accepted UVA's proposal and, on September 26, 2016, entered into a memorandum of understanding with UVA to conduct industrial hemp research.

UVA proposes to conduct agronomic studies as well as studies aimed at establishing new molecular breeding and genetic engineering strategies to specifically enhance the biological properties of the hemp plant. The principal investigator's goal is to develop a Virginia hemp cultivar.

2017 Growing Season

In advance of the 2017 growing season, VDACS will work with the research universities to distribute the hemp seed from its inventory, as requested by the universities. The agency also will issue new and renewal industrial hemp grower's licenses, as appropriate.

Appendix A

INVESTIGATION OF INDUSTRIAL HEMP FOR OIL AND BIOFUEL PRODUCTION IN VIRGINIA

Annual Report to
Virginia Department of Agriculture and Consumer Services

by

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August 30, 2016

Research on the growth of industrial hemp was conducted by James Madison University in cooperation with contract farmers as permitted by the federal Agricultural Act of 2014 and the Virginia Industrial Hemp Farming Act of 2015. Experiments were designed to address the following objectives:

Field based research (Dr. Renfroe and contract growers)

1. To determine how effectively hemp will grow in Virginia in the Ridge and Valley Province, examining growing conditions and analyzing soil properties
2. To analyze harvest methods and determine if conventional agricultural equipment (seed drillers and combines) can plant and harvest industrial hemp without major problems
3. To investigate the use of hemp seed oil in the production of fuels (biodiesel) and the use of press cake for livestock feed

University based research (Dr. Morton)

1. To explore the potential for the chemical conversion of hemp oil to produce a qualified quality biodiesel
2. To determine the potential for lignocellulosic derived biofuels
3. To develop a strong and extensive life-cycle systems overview

Site Selection

To address these objectives two sites were selected for growing hemp, one on either side of the Blue Ridge Mountains. One site was an upland site with clay soil located in Albemarle County, VA. The other site was a river bottom with sandy loam located in Rockingham County, Va. Sites were selected based on the participation of qualified farmers with appropriate agricultural equipment, experience, and a location that was not easily accessible by public, and where the crop could be visually screened. All participants in this research were properly licensed by the Virginia Department of Agriculture and Consumer Services.

Seed

Industrial hemp seed were imported from an international distributor in accordance with DEA regulations, US Customs, the USDA, and VDACS. A single cultivar of an oil seed variety was used throughout this experiment. Although advertised as a monoecious variety, the cultivar proved to be polygamodioecious in the field.

Albermarle Site

Approximately ten acres were planted in industrial hemp in Albemarle Co. on June 22. This farm is operated as an organic farming operation.The site had been prepared by disking several times, followed by an application of poultry litter at a rate of two tons/Ac in May. Five of the acres received an additional one ton/Ac poultry litter just before planting. The other five acres received no additional fertilizer and was used as a control plot for comparison. Seeds were planted using a grain drill (Fig. 1). Seeds were planted at a rate of 15.5 lb/Ac.

Germination was prompt and seedlings quickly became established (Fig. 2). Rainfall was unusually high on this site and damping off was observed among the seedlings shortly after emergence. Additionally, weed species became emergent and provided severe competition to the hemp plants. Redroot pigweed (*Amaranthus retroflexus*), spiny pigweed (*Amaranthus spinosus*) and lambsquarters (*Chenopodium album*) were especially abundant. Jimsonweed (*Datura stramonium*), foxtail (*Setaria* sp.) and other weeds were present in lesser amounts. Weeds eventually overtopped the hemp at this site. Although final yield data are not yet available for this site, it is expected that yield will be low due to several factors: (1) the planting rate was lower than it should have been, (2) rainfall following germination resulted in damping off, and (3) weeds were not controlled post-germination, which led to severe competition with the hemp. Toward the end of the growing season, plants were around two to three feet tall (Fig. 3). This site has been harvested by combine (Fig. 4), but the yield data are not yet available. Seeds are being cleaned and dried. No pressing for oil content has yet occurred.

Rockingham Site

Approximately ten acres were planted in industrial hemp in Albemarle Co. on June 27. The site had been prepared by disking. Seeds were planted using a grain drill (Fig. 5). Seeds were planted at a rate of 21 lb/Ac. On five of the acres, 100 lb/Ac of a mixture of urea/ammonium nitrate was applied to the fertilized site. The other five acres received no fertilizer and was used as a control plot for comparison.

Germination was prompt and shortly after germination, plants were irrigated with 0.3 in/Ac of water. During July, three additional irrigations of one-half in water per acre were applied. Weeds were not prevalent in the hemp field at this site (Fig. 6). Plants with staminate flowers developed first. By the first of August, hemp plants in Rockingham were approximately 6-8 ft in height (Fig. 7).

Weeds were present along the border of the field, but rarely present in the field under the hemp canopy. Redroot pigweed (*Amaranthus retroflexus*), spiny pigweed (*Amaranthus spinosus*) and lambsquarters (*Chenopodium album*) were especially abundant along with lesser amounts of Jimsonweed (*Datura stramonium*), Johnson grass (*Sorghum halapense*), velvetleaf (*Abutilon theophrasti*), morning glory (*Ipomoea purpurea*) and other weeds. In contrast to the Albemarle site, the hemp overtopped other plants and very effectively suppressed any weed competition. It would appear that a higher planting rate and getting quick canopy closure is important to establishing a quality hemp stand.

The only insect pests observed on the hemp were Japanese beetles and June bugs. They fed on anthers primarily and to a very small extent on leaves. There were some minor infestations of what appeared to be Sclerotinia on the hemp stems near the ground line, but this was not of any real consequence.

Plants developed pistillate flowers (Fig. 8) and seeds developed, but more pistillate flowers were produced than developed seed, indicating incomplete pollination. This site has yet to be harvested, so no yield data are available. Harvesting should occur in early September.

Products
Seeds from both sites will be pressed for oil. Hemp oil will be processed into biodiesel. Press cake will be used for animal feed and, if possible, hemp stalks will be chopped and used for animal bedding. If we cannot recover the stems, they will be bush-hogged and plowed under.

Progress
This first field trial is nearing the conclusion. Harvesting will soon be completed and product yields will be determined. Growing conditions will be analyzed to determine recommendations for next year. We can conclude at this point that planting should occur earlier in the season, and seeding rates should be increased. There is a need to evaluate additional cultivars, and field management strategies need to be further developed.

Figure 1. Planting seed on Albemarle site with drill planter

Figure 2. Hemp plant producing pollen.

Figure 3. Hemp stand on Albemarle site.

Figure 4. Harvesting by combine.


Figure 5. Planting seed on Rockingham site with drill planter

Figure 6. Young hemp seedlings in Rockingham.


Figure 7. Hemp stand on Rockingham site.

Figure 8. Hemp developing pistillate flowers.

Appendix B

Publication Year 2016

Annual Report

Title: Evaluating growth and productivity of several industrial hemp (*Cannabis sativa* L.) varieties in Virginia

Principal Investigator

Dr. Maru K. Kering,
Agricultural Research Station -Virginia State University

Non-Technical Summary

In 2016, five hemp varieties (One Fiber-type) and four grain-type varieties where evaluated in small plot studies at Randolph Farm, the Virginia State University Research and Demonstration farm near Ettrick, VA. Nitrogen fertility study was carried out independently for one grain- and one fiber-type variety. Variety trial was done for four grain –type varieties. Despite late planting, initial assessment showed that these foreign-developed varieties can grow under Virginia conditions. Preliminary result indicates that fiber-type variety produced dry biomass (leaf + stem) of up to 10 Mg ha^{-1}. While a few insect pest were observed, bird infestation was a major problem with a different wild bird species visiting grain-type hemp varieties plots on a regular basis as grain maturity progressed.

Major goals of the project

The project seeks to evaluate both fiber- and grain-type hemp varieties for establishments and growth performance in Virginia. The project seeks to determine; 1) Industrial hemp varieties that are suited to the southeast Virginia conditions; 2) The effect of nitrogen fertilizer on biomass, grain yield and grain quality

Expected Outcome

Outcome expected from this project includes; 1) Information on fresh/dry biomass of fiber- and seed yield of grain-type hemp varieties under different nitrogen fertilizer levels; 2) Information on growth and seed yield of different grain-type industrial hemp varieties at what would be considered optimal nutrient fertilizer levels.

What was Accomplished

One fiber-type and one grain-type industrial hemp varieties were evaluated for nitrogen fertilizer response. These varieties were planted on May 27, 2016. Seeding rate and row spacing were 22 kg ha^{-1} and 38 cm (grain-type) and 67 kg ha^{-1} and 19 cm (Fiber-type). Nitrogen fertilizer rates was up to 100 and 250 kg ha^{-1} for fiber-type and grain-type variety, respectively. For the variety trial experiments, four grain-type varieties were planted on June 7, 2016. For variety trial, N, P, and K were applied based on the recommendation of soil analysis report. The crop showed good establishment and growth. The fiber-type variety was harvested at late flowering stage prior to seed maturity, and dry biomass determined.

Field Growth, Observations, and Data Collection

There was good seedling emergence and early crop growth for both fiber- and grain-type varieties (Figure 1a & 2a). Later in the season fiber-type height reached up to 7 feet tall (Figure 1b) while grain-type where shorter at about 4-5 feet tall (Figure 2b). While weed were removed by tilling to allow vigorous crop growth, pest infestation were observed in late season. Insect pest resulted in some leaf damage while infestation by wild bird let to some seed lose in grain-type varieties.

During harvesting of fiber-type variety, representative row length within the middle rows were harvested for biomass. The material was weight fresh, dried and reweight. Expected yield per hectare basis was calculated. In the grain variety, plants within a length of 3 m in the middle two rows were harvested, bagged and dried. Grain yield will be determined after it is shelled**.**

Figure 1a Figure 1b

Plant growth in fiber-type hemp one month after planting (Figure 1a) and in late season (Figure 1b) at Virginia State University Research and Demonstration Farm in 2016.

Figure 2a Figure 2b

Plant growth in grain-type hemp one month after planting (Figure 2a) and in late season (Figure 2b) at Virginia State University Research and Demonstration Farm in 2016.

Future Plans

In 2017, Virginia State University will continue varietal evaluation and nitrogen fertility studies. Beside varieties planted in 2016, additional varieties may be included in 2017. We also plan to conduct the planting date study in 2017 for both fiber- and grain-type varieties. Analysis of harvested material for fiber and grain characteristics will be conducted as possible. Recommendations on adapted varieties, optimum fertilizer rates and planting dates will be made based on data collected over a three year period.

In addition to these efforts, we will continue to build relationships with others including private sector participants in anticipation of future collaborative work if and when licensing barriers are removed and industrial hemp production allowed in the Commonwealth of Virginia.

Appendix C

Commonwealth Hemp Trials Report, 12 Oct 2016

Virginia Tech's research efforts with industrial hemp began in 2015 following passage

Dr. John Fike took the lead in the university's proposal development and began working with VDACS staff in the Office of Planning and Policy to obtain an industrial hemp grower's license and to determine what hemp varieties might be tested in 2016. Efforts to narrow down and secure available hemp lines continued into 2016. VDACS staff were invaluable to university personnel through their efforts to get seed out of other countries and into the hands of university researchers all while ensuring that our procedures were within the strictures of the law.

Virginia Tech researchers planted hemp at 3 sites in 2016. Sites in Orange and Blacksburg VA were used to test varietal differences under grain and fiber management (Table 1). A site in Blackstone, managed by Dr. Carol Wilkinson, a single variety (Felina 32) was used to determine the effects of fertility management and establishment practices on both hemp grain and hemp fiber production.

Table 1. Varieties tested by location and management in VT hemp trials, 2016

	Fiber	Grain
Orange	Canda	Canda
	Carmagnola	Carmagnola
	Felina 32	Delores
	Fibranova	Felina 32
		Joey
Blacksburg	Campana Eletta	Campana Eletta
	Canda	Canda
	Carmagnola	Carmagnola
	Felina 32	Delores
	Fibranova	Felina 32
	Glesia	Glesia
	Gliana	Gliana
	Zolotonosha 15	Joey
		Zolotonosha 15

Variety trials

A set of studies was conducted to determine the potential productivity of several hemp varieties in different locations in Virginia. Hemp varieties obtained from Canada and several countries in Europe were established in Orange and Blacksburg, VA. Experimental design for each study was a randomized complete block with three replications.

At Orange, VA, the plot area used for hemp trials had been under limited management – grass cover with routine mowing – for the past several years. Vegetation was killed with glyphosate in spring and plots were subsequently tilled to eliminate the residual vegetation. Following a soil test, all plot areas received 40 lb (18 kg) of phosphorus as triple super phosphate. On June 30, four hemp lines were planted for the fiber management trial and five lines were planted for the grain management study. Plots for both studies were 5 ft x 16 ft (1.52 m X 4.88m). Hemp seed were planted at 60 lb/ac (53 kg/ha) for the fiber plots, with seven rows planted in seven inch (15.75 cm) row-to-row spacing. Grain plots were planted at 20 lb/ac (17.8 kg/ha) using four rows per plot with 14 inch (31.5 cm) row-to-row spacing. Plots were seeded using a Hege small plot grain drill. Plot borders were sown with a mixture of Fedora 17 and Futura 75. Within a week following seeding, nitrogen (N) was applied to the fiber and grain plots. However, an error resulted such that applications of 200 lb N/acre (178 kg/ha) were applied to fiber plots and 60 lb N/ac (53 kg/ha) were applied to the fiber plots.

In Blacksburg, VA, the sited used for hemp research had been under grain crop management and had been planted to corn in the previous season. Hemp plots were tilled in the spring and fertilized with 25 lb (11.4 kg) of phosphorus as triple super phosphate and urea N was applied at 60 lb N/ac (53 kg/ha) for fiber plots and 200 lb N/acre (178 kg/ha) for grain plots. Plots were sprayed for weeds about 10 d prior to plot establishment. Plots for both grain and fiber were 5 ft x 13 ft (1.52 m X 3.96 m) and seeded using a Hege small plot grain drill in the same configurations as used at Orange. Plots were established July 7 (just over 2 weeks after the summer solstice – which is quite late for hemp plantings). An additional six hemp lines secured by VDACS arrived too late to be planted in 2016. Grain plots were treated with Assure II (300 mL/A) with a surfactant (Meherrin 80-20 at 1 pint/gal) for grass week control approximately 6 week post plant

Hemp plots were harvested for fiber on August 25 and 26 in Orange and Blacksburg, respectively. Plant heights were measured in each plot and recorded at the time of harvest. Samples from each study were cut with hand shears from within 3, 0.25-m^2 quadrats at 10 cm above the soil surface. Biomass from each quadrat was weighed on a hanging field scale and subsampled and weighed to determine plant dry matter for use in yield estimates. Stem diameter at the base also was measured on a subset of plants from each plot. Biomass was then dried at 55°C for a minimum of 48 h to determine plant dry matter percent. For the varieties tested at both sites, biomass yield results were about 3 fold greater in Blacksburg than Orange, despite a shorter growing season (Table 2). Other data on height, stem diameter are not included here but generally, larger stem diameter and height were associated with greater biomass yields. Interestingly, stand count at the end of the season was not well correlated with biomass yield.

Fibers from both sites were field retted in Blacksburg to facilitate ease of access for retting and final collection. We currently are in the process of determining ways to simplify the decortication process for these retted materials before we gather fiber component (bast and hurd) yield. Once these samples are processed into bast fibers, we will pass these on to colleagues whose work is to understand fiber properties.

Grain samples have been threshed from the hemp stalks but need to be dehulled to complete yield estimates. Given the late start to our studies, we do not have high expectation of grain yields. Grain samples will be saved for additional analysis as resources allow.

Grain plots were harvested on September 14 and 15 for the two respective sites. Samples from each study were cut with hand shears from within 3, 0.25-m^2 quadrats. Biomass was dried at 55°C for a minimum of 48 h to determine plant dry matter percent. Grain has been threshed from these samples but final yield results will not be available until after seeds have been dehulled.

VDACS personnel sampled hemp plant material for Δ-9 THC analysis at both sites. Samples were collected in Orange from the fiber plots before the fiber harvest but were not sampled from grain plots prior to grain harvest. Samples from Blacksburg were sampled before both fiber and grain harvest.

Table 2. Raw (unretted) biomass yield for and final stand counts for fiber trials conducted in 2016.

Variety	Orange	Blacksburg	Orange	Blacksburg
	----Biomass yield, tons/acre----		----Plants / m^2----	
Campana Eletta	--	2.99	--	180
Canda	0.46	1.87	97	131
Carmagnola	0.80	2.64	46	56
Felina 32	0.71	2.57	114	160
Fibranova	0.79	2.65	89	125
Glesia	--	1.89	--	77
Gliana	--	2.18	--	71
Zolotonosha 15	--	2.22	--	94
S.E.	0.04	0.11	--	--

Hemp plots were monitored with some frequency to document the progress of crop development. Weed pressures were more of a problem at Kentland than at other sites due to some of the initial stand management. Plots that had been prepared for planting in late June had to sit idle for a couple of weeks as weather and other demands on planting equipment needed to be accommodated. This provided a window of time for some weeds to germinate and these would put some pressure on the new hemp crop, particularly the less dense stands planted under grain management. We were able to treat a few weeds with Assure II late in the growing season (end of August) and the weed specialist was pleasantly surprised with the limited amount of herbicide damage to the crop. Had the application been timely (i.e., earlier), he speculated it would have had little effect on plant development. However, by the time the plots were harvested, the residual effects of herbicide appeared minimal.

Fertility and establishment studies

Felina 32, a monoecious variety from France, was used in all studies. The experimental design for each study was a randomized complete block with four replications. Plot size was 6’ x 20’. The seeding rate was 40, 60, and 80 lbs/A drilled for the grain, dual, and fiber tests, respectively. Row spacing was 14” in the grain test and 6” in the fiber and dual tests. The soil at the site is an Appling fine sandy loam. The site was previously in ryegrass which was sprayed with Paraquat at 2 pints/A on 13 June 2016.

Conventional tillage was used to prepare the site and 200 lb/A of K_2O (0-0-60) was applied. A second dual purpose test was conducted using no-tillage.

Plots were seeded on 20 June 2016 with a Great Plains no-till drill at an average planting depth of 0.25 in (0.5 cm) or less. Nitrogen was applied by hand to each plot as ammonium nitrogen (34-0-0) prior to seeding. The nitrogen rates for the fiber test were 0, 40, 80, and 120 lb N/A (0, 35.6, 71, and 107 kg/ha). The nitrogen rates for the grain test were 0, 80, 160, and 240 lb N/A (0, 71, 142, and 214 kg/ha). The nitrogen rates for the dual purpose tests were 0, 40, 80, and 160 lb N/A (0, 35.6, 71, and 142 kg/ha). Two dual purpose tests were conducted; one test was seeded on conventionally prepared land and the second test was no-tilled. Plots were sprayed on 30 June 2016 (10 days after seeding (DAS)) with Assure II (300 mL/A) with a surfactant (Meherrin 80-20 at 1 pint/gal) for crabgrass control. Plots were sprayed on 15 August 2016 (56 DAS) with 5 oz/A of Blackhawk to control corn earworms, yellow striped armyworms, and budworms. American goldfinches and doves were a significant problem beginning in mid to late August. The birds are light enough they can perch on the plant and eat the seed. Fishing line will be strung across the top of the plots in a crosswise pattern to deter birds in 2017 tests. Plots were not irrigated in 2016 but irrigation should probably be considered in the future.

Plant density, plant height, stalk diameter, fiber yield, and grain yield were measured. Plant density was determined by counting the number of plants per square foot at 10 DAS and number of plant stems per square foot after harvest. Five counts were made per plot. Plant height (cm) was determined by measuring 10 randomly selected plants per plot the day of harvest. Stalk diameter (mm) of 10 randomly selected stalks was measured with a caliper 10 cm above the soil surface the day after harvest. A 5' x 15' (1.5 X 4.6 m) section of each plot in the fiber test was harvested with a Wintersteiger self-propelled forage harvester and total plant material weight recorded (lbs) as an estimate of fiber yield. Grain yield was determined by manually harvesting all heads from a randomly selected 16 ft^2 (1.5 m^2) area avoiding plot edges. Grain was thrashed and cleaned by hand, the number of seed counted and weighed (lbs/A). Dual test plots were harvested first for grain and then for fiber. The fiber, grain, and dual tests were harvested on 31 August 2016 (72 DAS), 13 September 2016 (85 DAS), and 23 September (95 DAS), respectively.

Assure II provided affective crabgrass control and did not negatively impact the young hemp plants. Assure II is labeled as a single post-emergent spray for weed control in industrial hemp in Canada. Blackhawk provided effective control of worms. Significant differences were observed among nitrogen rates for plant height and weight in the fiber test (Table 3). Plant height was significantly shorter at 0 lb N/A compared to plant height at 80 and 120 lb N/A. Plant weight at 0 lb N/A was significantly lower than the other three nitrogen rates. There was no significant difference in plant weight at 40, 80, and 120 lb N/A although plant weight increased with increasing nitrogen rate. In contrast, no significant differences were observed among nitrogen rates for plant density and stem diameter in the fiber test. There was no significant difference among the four nitrogen rates for plant density, plant height, stalk diameter, and plant weight in both dual purpose tests (Tables 4 and 5). Plant weight did increase with increasing nitrogen rates but the increase was not significant. Thicker stem diameters, taller plant heights, and higher plant weights in the dual purpose no-tillage trial as compared to the dual purpose conventional tillage trial indicate the improved water retention and less evaporation of the no-tillage test was beneficial for plant growth throughout the season. Plants in the no-tillage plots were visibly taller throughout the growing season (data not recorded). Significant differences were observed among nitrogen rates for plant density at harvest in the grain test (Table 6). There were significantly more plants per square foot at 0 lb N/A compared to 160 and 240 lb N/A. In contrast, no significant differences were observed among nitrogen rates for plant density at 10 DAS, stem diameter, and plant height in the grain test. Grain is being thrashed and cleaned.

Table 2. Data from fiber test conducted in 2016.

	Plant Density		Stem	Plant	Plant
N rate	10 DAS	Harvest	Diameter	Height	Yield
lb/A	plants/ft^2		mm	cm	lb/A
0	24.85	20.25	2.96	75	4413
40	22.00	20.75	2.93	84	5221
80	22.25	18.55	3.17	94	5846
120	22.80	16.60	3.11	93	5932
LSD (*P*=0.05)	ns	ns	ns	13	766
CV (%)	12.98	15.34	12.41	9	9

Table 3. Data from dual purpose test conducted in 2016.

	Plant Density		Stem	Plant	Plant
N rate	10 DAS	Harvest	Diameter	Height	Yield
lb/A	plants/ft^2		mm	cm	lb/A
0	12.80	7.42	3.63	89	3789
40	11.60	8.66	4.38	106	4713
80	12.40	7.45	4.33	110	4464
160	12.35	7.55	4.47	117	5672
LSD (P=0.05)	ns	ns	ns	ns	ns
CV (%)	9.59	15.83	16.01	12	21

Table 4. Data from dual purpose no-tillage test conducted in 2016.

	Plant Density		Stem	Plant	Plant
N rate	10 DAS	Harvest	Diameter	Height	Yield
lb/A	plants/ft^2		mm	cm	lb/A
0	12.80	5.56	5.14	136	4566
40	15.20	7.52	6.01	141	5608
80	14.65	6.81	5.64	138	5642
160	15.20	7.62	5.80	136	5800

LSD (P=0.05)	ns	ns	ns	ns	ns
CV (%)	31.68	20.84	17.88	5	19

Table 5. Data from grain test conducted in 2016.

	Plant Density		Stem	Plant
N rate	10 DAS	Harvest	Diameter	Height
lb/A	plants/ft^2		mm	cm
0	7.35	4.19	4.18	118
80	8.30	3.75	4.57	116
160	6.80	3.42	4.72	119
240	6.50	3.12	4.75	119
LSD (P=0.05)	ns	0.75	ns	ns
CV (%)	17.67	12.91	9.75	7

Observations and future work

As noted at all sites for the two studies, numerous insect and wildlife species were observed in the plots over the summer. No efforts were taken to reduce herbivory by insects or wildlife for the variety trials, so the data from those sites are certain to underestimate the potential grain yields of this plant. Virginia Tech's entomologist was surprised by the number of insect species that were feeding on the plants in Blacksburg and this is an area we intend to follow.

Wildlife issues are also of importance given the high level of predation on the grains by several bird species. While this may be a challenge for production, hemp use may present an opportunity to support the game bird industry and to bolster quail populations. Opportunities to investigate these interactions are being explored.

Questions have arisen about the use of the plant and insecticidal treatments and their effects on product yield and quality. This issue will be particularly important if hemp is grown for nutraceutical compounds that require high degrees of purity for nutritional and health markets (as opposed to grain or fiber). Of course this may or may not be an issue depending on the processes used to collect and purify hemp. We hope to explore how hemp agronomic management practices affect production of cannabinoids and how successful subsequent process chemistries are in terms of extracting cannabinoids with a high level of purity.

Our initial results indicate that despite poor establishment timing, hemp can be productive in Virginia. Large differences have been observed by site, suggesting hemp is sensitive to factors such as soil type and available moisture. How these factors affect productivity with timely planting remains to be seen. More varieties need to be screened and greater efforts to understand agronomic management impacts and the downstream effects on product quality and we are moving in those directions.