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Hemp Nutrient Disorders Scientific Research Update from NC State:

"Characterization of Nutrient Disorders of Cannabis sativa" has been published with open access in Applied Sciences

We at NC State have been focusing our research and publishing efforts to help fill the plant nutrition science void in cannabis. Our research has already garnered a few publications. A summary of our most recent publication which is open access is the focus on the second half of this article. If you or your grow operation needs information on nutrient disorders,

symptomology, or critical leaf tissue values for cannabis you may want to also utilize our resources published:

Nutrient Matters Series (a nutrient related article has been highlighted every issue for the past 9 months) in Cannabis Business Times.

Our articles focused on: Substrate pH, Electrical Conductivity, Nitrogen Management, Sulfur, Magnesium, PourThru Nutrient Monitoring, Balancing Nutrients, Alkalinity, and Tissue Analysis.

(https://www.cannabisbusinesstimes.com/ article/balancing-the-nutrient-equationcannabis-cultivation/).

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Figure. 1. The nutrient disorder system at NC State University. Photo: NC State Research.

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Leaf Tissue Standards.

Expanding leaf tissue nutrient survey ranges for greenhouse cannabidiol-hemp. This scientific article highlights critical leaf tissue values for different high CBD cultivars (https:// dl.sciencesocieties.org/ publications/cftm/abstracts/ 5/1/180081? access=0&view=article)

The information above and our recent published nutrient disorder guide are important given the recent changes in legislation both at the federal and state levels, there has been increased interest in the growing, processing, selling, and using products containing cannabidiol (CBD) derived from hemp flowers. Hemp has historically been grown for fiber and seed and due to recent changes in legislation it is being grown for flowers. Hemp grown for flowers (floral hemp) follows a horticultural production model either in a greenhouse or bedded fields compared to fiber and seed hemp which follow an agronomic production model.

Plant tissue analysis has been used extensively for many decades to evaluate the nutritional status of a crop. Survey ranges for *Cannabis sativa* in greenhouse nursery production have been published by Bryson et al. (2014). Recently, a survey of five hemp cultivars in greenhouse production by Landis et al. (2019) as part of hemp partnership between NC State University (NCSU) and the North Carolina Department of Agriculture and Consumer Services (NCDA&CS)



Figure 2. Greenhouse view of the nutrient disorder system at NC State University. Photo: NC State Research.

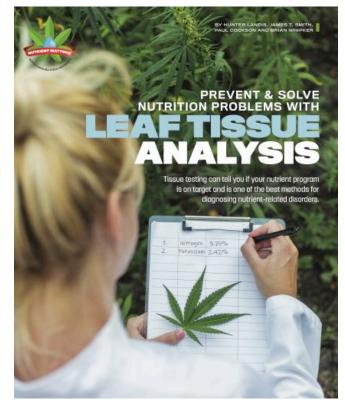


Figure 3. NC State University plant nutrition article series in Cannabis Business Times.

was published. These tissue values are useful for cannabis growers as they aid in fertility management.

Nutrient Disorders. Our NCSU and NCDA&CS partnership also conducted research investigating the crucial nutrient deficiency levels in the leaf tissue of cannabis. Once a plant begins showing visual symptoms of impaired growth, reduction in plant health or yield is implicit. In our study, when plants began showing deficiency symptoms for each nutrient, most recently mature leaf samples were analyzed for that nutrient. This is information can used by growers and researchers to confirm visual diagnosis with leaf concentrations.

Additionally, visual guides of nutrient deficiencies in cannabis supported with leaf tissue analysis and documenting a progression of symptomology have not been published. Tracking the specific symptomologies of various nutritional disorders over time is important because symptomologies change in appearance and location as the deficiency progresses making correct diagnosis challenging. Therefore, our study was conducted to provide cannabis growers and researchers with descriptions of nutrient disorders, high quality images to track the progression of these disorders, and leaf tissue nutrient concentrations associated with documented deficiency symptomology.



Figure 4. Nitrogen deficiency occurring on rooted hemp cuttings. Photo: Brian Whipker

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Article		
Characterization of Nutri	ient Disorders	
of Cannabis sativa		
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Received: 23 September 2019; Accepted: 9 October	r 2019; Published: 18 October 2019	check for updates
Abstract: Essential plant nutrients are neede growth or yield. Plant tissue (foliar) analysis crops. Symptons of nutrient deficiency occur growth or yield is negatively impacted and new entbene stabilished for cannabis. To estal symptoms are expressed, Cannabis and the plants received a complete modified Hoagh treatments were induced by increasing the eler Plants were wontored daily and, once symp elements was performed by most recent mat photographs of nutrient disorder symptome tracked through initial, intermediate, and adv diagnose nutrient disorders in Cannabis taitia Keywords: macronutrients, micronutrients; c hemp; diagnostics; plant tissue analysis; CBD	s is the standard method for measurin r when those tissue concentrations fal can serve as a visual diagnostic tool ms and their corresponding plant tiss. Ibish nutrient concentrations when def ' plants were grown in silica sand cul land's all-nitrate solution, whereas r ment tenfold higher than the complete ptoms manifested, plant tissue analysis ure leaf (MRML) tissue analysis, and ology were taken. Symptoms and pr vanced stages. Information in this stue acannabis; deficiency; toxicity; fertility	ig those levels in to a level where for growers and icconcentrations icidency or toxicity ture, and control utrient-deficient nutrient. Toxicity nutrient formula. is of all essential descriptions and oggressions were dy can be used to
I. Introduction		
Due to recent changes in legislation both a nterest in the growing, processing, selling, and u rom hemp flowers. Hemp is legally defined a THCl concentration no greater than 0.3% in a strains with a THC concentration greater than <i>chambis</i> satire contains over 100 cannabinoids rundbis satire contains over 100 cannabinoids rundbis durit contains over 100 cannabinoids such as imiliar to marginana but without the psychoact Being grown for flowers. Hemp grown for flor ordel either in a greenhouse or bedded field gronomic production model.	using of products containing cannabidi as Cannudis sativa strains with a tetral any part of the plant (Congress, [1,2] 0.3% in any part of the plant are consis s, which include THC and CBD. It is ported health benefits from marijuan ss CBD. The broad interest in CBD is fo tive effects of THC. r and seed, and due to recent changes: wwers (floral hemp) follows a horticul	ol (CBD), derived hydrocannabinol). Cannabis sativa (dered marijuana. well known that a, which may be or health benefits in legislation, it is tural production

Figure 5. Hemp nutrient disorder scientific article in Applied Sciences.

Our goal was to present this information in a freely available fashion to cannabis growers and scientific researchers. In this end, we purchased open access of the research results. Thus, our work and the associated data and pectoral guide can be downloaded for free by those who are interested. The links to the scientific publication can be found at:

"Characterization of Nutrient Disorders of *Cannabis sativa*" by Paul Cockson, Hunter Landis, Turner Smith, Kristin Hicks, and Brian Whipker has been published in Applied Sciences and is available free online:

Abstract: <u>https://www.mdpi.com/</u> 2076-3417/9/20/4432 HTML Version: <u>https://www.mdpi.com/</u> 2076-3417/9/20/4432/htm PDF Version: <u>https://www.mdpi.com/</u> 2076-3417/9/20/4432/pdf

Future. With so many needs from industry, and so little information, the team at NC State is continuing our cannabis plant nutrition research. We currently have a number of research projects and collaborations. Stay tuned for more research, outputs, and publications! Literature Cited

Bryson, G.M., Mills, H.A., Sasseville, D.N., Jones Jr, J.B. and Barker, A.V., 2014. Plant analysis handbook III: A guide to sampling, preparation, analysis and interpretation for agronomic and horticultural crops. *Inc. Athens, GA, USA*.

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In cooperation with our local and state greenhouse organizations



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