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PREVISÃO DE PRODUTIVIDADE E QUALIDADE DE CENOURA UTILIZANDO APRENDIZADO DE MÁQUINA

Yara Karine de Lima Silva

Engenheira agrônoma

2024

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YARA KARINE DE LIMA SILVA – nascida em Cedro do Abaeté, Minas Gerais, no dia 06 de dezembro de filho de Divino Eustáquio de Lima e Mary Aparecida Pessoa. Cursou os ensinos fundamental e médio na Escola Frederico Campos em sua cidade de origem, finalizando-os no ano de 2013. Ingressou no ensino superior no ano de 2014 no curso de Engenharia Agronômica pela Universidade Federal de Viçosa (UFV), Câmpus de Rio Paranaíba - MG, obtendo o título de Engenheira Agrônoma em fevereiro de 2019. Durante a graduação foi bolsista de Iniciação Cientifica pelo Conselho Nacional de Desenvolvimento Científico e Tecnológico durante os anos de 2016 e 2017 no Grupo de Estudos em Solos e Suas Interfaces com a Agroecologia (GESSIA) sob orientação do Dr. André Mundstock Xavier de Carvalho, gerando trabalhos científicos e participação em eventos acadêmicos-científicos. Durante a graduação ministrou monitorias remunerada e voluntária das disciplinas de Gêneses do solo, Pedologia, Geologia básica, Fertilidade do solo e tutoria especial de Bioquímica Fundamental. Em março de 2019 iniciou o Mestrado em Produção Vegetal na mesma Universidade de sua graduação, participando ativamente no laboratório de Solos e Mecanização do Grupo de Mecanização Agrícola e Solos (GESOL) sob orientação do Dr. Alberto Carvalho Filho. No final de 2020, ainda no mestrado, atuou profissionalmente como Assistente Técnica em culturas anuais (soja e milho) e na cultura perene do café no Triângulo Mineiro e Alto Paranaíba. Em janeiro de 2021 obteve o título de Mestre em Produção Vegetal. Após o término do Mestrado, atuou como Analista de Mercado e Produto na região de Patrocínio - MG antes de ingressar no Doutorado em junho de 2021. O Doutorado em Ciência do Solo foi cursado na Universidade Estadual Paulista “Júlio de Mesquita Filho” em Jaboticabal, São Paulo, sob orientação do Dr. Carlos Eduardo Angeli Furlani. Ao final do Doutorado tem atuado como Analista Técnica Comercial Sênior pela multinacional Yara Fertilizantes nas regiões do Noroeste Mineiro e Leste Goiano. Em janeiro de 2024 submeteu-se à banca examinadora para obtenção do título de Doutora em Agronomia (Ciência do Solo).

“Pensei mais um milhão de vezes em parar,

em desistir de mim por não acreditar.

E hoje eu sou o meu melhor motivo pra

comemorar. O ontem passou e o amanhã

ainda não é eu. Tudo o que mudou me

transformou no que hoje sou eu.”

(Kell Smith)

Dedico aos meus pais e à toda a minha família. Aos meus amigos e profissionais que sempre me deram o suporte necessário para que eu não desistisse! E principalmente aos que estiveram comigo desde o mestrado me mantendo forte, me apoiando e me motivando para que eu me tornasse cada dia melhor. Meu muito obrigada. Sem vocês nada disso se concretizaria.

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SUMÁRIO

PREVISÃO DE PRODUTIVIDADE E QUALIDADE DE CENOURA UTILIZANDO APRENDIZADO DE MÁQUINA

RESUMO

A cenoura (*Daucus carota* L.) destaca-se entre os principais vegetais cultivados globalmente. A implementação de sistemas agrícolas baseados em inteligência artificial podem os tornar mais eficientes e sustentáveis nas diferentes esferas da produção. No contexto dessa abordagem, o híbrido EX 4098 de cenoura foi testado em dois experimentos durante a safra de verão em Rio Paranaíba /MG, visando otimizar a produção e impulsionar a agricultura sustentável.Com o objetivo de prever a produtividade e a qualidade da cultura, foram realizadas amostragens das raízes em 200 pontos de 0,25 m² com grade amostral de 30 m x 30 m, em duas épocas de coleta (82 e 116 dias após semeadura) em ambos os experimentos. Para a produtividade quantificou-se a biomassa fresca total, parte aérea e raiz e biometria das raízes (comprimento e diâmetro). A qualidade das raízes foi avaliada na subamostragem de três cenouras pela concentração de sólidos solúveis totais (°Brix) e firmeza. Os índices de vegetação NDVI, RDVI, EVI e SAVI foram extraídos da PlanetScope CubeSat. Os parâmetros mais importantes verificados na análise dos componentes principais foram submetidos aos algoritmos *artificial neural network* (ANN), *random forest* (RF) e *regressão linear múltipla* (RLM) para a modelagem da cultura. Para a estimativa de produtividade, o modelo ANN foi superior à RF e ao RLM, respectivamente. Os índices SAVI e NDVI destacaram-se como indicadores significativos para predizer a produtividade da cultura. No entanto, é importante esses algoritmos não foram capazes de modelar a qualidade da cenoura. Sugere-se que estudos futuros explorem o potencial preditivo dos parâmetros °Brix e Firmeza para avaliar e aprimorar a qualidade da cenoura.

Palavras-chaves: Solo, Mapeamento, Qualidade, Índice de vegetação.

PREDICTING CARROT YIELD AND QUALITY USING MACHINE LEARNING

ABSTRACT

Carrot (*Daucus carota* L.) stands out among the main globally cultivated vegetables. The implementation of artificial intelligence-based agricultural systems can make them more efficient and sustainable across different spheres of production. In the context of this approach, the carrot hybrid EX 4098 was tested in two experiments during the summer crop in Rio Paranaíba/MG, aiming to optimize production and boost sustainable agriculture.In order to predict crop productivity and quality, root samples were taken at 200 points of 0.25 m² with a sampling grid of 30 m x 30 m, at two collection times (82 and 116 days after sowing) in both experiments. For productivity, total fresh biomass, aboveground and root biomass, and root biometrics (length and diameter) were quantified. Root quality was assessed by sub-sampling three carrots for total soluble solids concentration (°Brix) and firmness. NDVI, RDVI, EVI, and SAVI vegetation indices were extracted from the PlanetScope CubeSat. The most important parameters verified in the principal component analysis were subjected to artificial neural network (ANN), random forest (RF), and multiple linear regression (MLR) algorithms for crop modeling.For productivity estimation, the ANN model outperformed RF and MLR, respectively. SAVI and NDVI indices stood out as significant indicators for predicting crop productivity. However, it is important to note that these algorithms were unable to model carrot quality. It is suggested that future studies explore the predictive potential of °Brix and firmness parameters to assess and improve carrot quality.

Keywords: Soil, Mapping, Quality, Vegetation index.

1 INTRODUÇÃO

A produção de cenouras apresenta desafios complexos, que vão desde a otimização da qualidade das raízes até a previsão da produtividade. A cenoura é uma hortaliça geocárpica, crescendo subterraneamente, o que dificulta a avaliação direta de sua parte desejada, as raízes. Fatores como variação genética, condições ambientais e práticas de cultivo influenciam a qualidade das cenouras, tornando essencial a busca por abordagens inovadoras na tomada de decisões.

A qualidade da cenoura de mesa é fortemente influenciada por características visuais, como uniformidade de tamanho e formato, além de sabor, aspectos fundamentais para sua valorização no mercado e preferência dos consumidores. Nesse contexto, variáveis como °Brix (sólidos solúveis totais) e firmeza tornam-se críticas, mas a modelagem preditiva desses parâmetros ainda é uma lacuna a ser preenchida. A integração de tecnologias como sensoriamento remoto (SR) como a coleta de dados via imagens de satelite e inteligência artificial (IA) emerge como uma solução promissora para superar os desafios específicos da cenoura, possibilitando uma avaliação mais completa.

A utilização de ferramentas de monitoramento para acompanhar as características de produtividade e qualidade da cenoura é essencial para embasar decisões no campo. Ao investigar a variação dessas características, é possível delimitar unidades de gestão diferenciadas (UGDs) e identificar locais com maior potencial produtivo da cultura, adaptando-se aos diferentes usos. Esses locais de maior potencial produtivo podem otimizar o uso de recursos, como adubação, defensivos agrícolas, densidade de plantio e época de semeadura. Áreas identificadas com produção de cenouras com teores mais elevados de açúcares podem ser destinadas à produção de energia ou receber maior valorização no mercado consumidor. Além disso, a capacidade de prever a produtividade e qualidade da cenoura antes da colheita abre oportunidades para negociações futuras.

Neste contexto, o presente estudo visa estabelecer relações funcionais entre diversas variáveis, como a massa fresca total, a massa da parte aérea e da raiz, o comprimento, diâmetro, °Brix e firmeza das raízes, integrando-os com índices de vegetação e inteligência artificial. A ausência de pesquisas que explorem de maneira simultânea a produtividade e a qualidade das raízes de cenoura destaca a importância desta abordagem, proporcionando insights valiosos aos produtores e contribuindo para avanços significativos na produção sustentável da cultura. A tese inclui uma revisão de

literatura aprofundada sobre o tema, fornecendo uma base sólida para a análise dos resultados obtidos no experimento.

6 CONSIDERAÇÕES FINAIS

Os índices SAVI e NDVI mostraram-se promissores em comparação aos índices RDVI e EVI na previsão da produtividade de cenoura. Os modelos ANN, RF e RLM demonstraram ser eficazes na modelagem da produtividade da cultura. A análise de componentes principais revelou a influência temporal nas variáveis espectrais, o que pode ser útil para otimizar o monitoramento da cultura ao longo do tempo. Apesar da qualidade não ter sido modelada, os resultados aqui obtidos trazem contextualização metodológica que podem incentivar pesquisas futuras.

Aqui, propomos encontrar respostas no campo que refletissem em ganhos múltiplos no âmbito econômico, social e ambiental, contemplando sobretudo os objetivos de desenvolvimento sustentável da ONU: ODS #02, ODS #10, ODS #12 e ODS #17. O desenvolvimento de novas tecnologias que proporcionam melhorias na qualidade dos alimentos vai ao encontro do fomento da segurança alimentar e saúde humana. Isso permite alcançar a melhoria da gestão e governança de forma responsável, reduzindo os impactos ambientais e otimizando a produção de alimentos. Pelos objetivos de desenvolvimento sustentável, zerar pobreza (ODS 2) e introduzir tecnologias de construção de resiliência em agroecossistemas são indiscutíveis à segurança alimentar e qualidade de vida.

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