MINISTÉRIO DA EDUCAÇÃO

INSTITUTO FEDERAL DO ESPÍRITO SANTO

CONSELHO SUPERIOR

RESOLUÇÃO DO CONSELHO SUPERIOR Nº 18/2019,
DE 1 DE JULHO DE 2019

ANEXO III – Relatório Individual de Trabalho

Nome: Elcio das Graça Lacerda	Matrícula Siape: 6050098
Classe / Nível: D - 401	
Lotação::Ifes Campus Santa Teresa/CGEN/ Curso de Agronomia	
Período de avaliação: Relativo ao primeiro semestre letivo de 2021/2	

Justificativa de cumprimento

1 - ATIVIDADE DE ENSINO

1.1 - Avaliação discente

Não houve avaliação discente devido às APNP

1.2 - Disciplinas Ministradas

Diário 357409 20212.AGROP.2A AGROP AGROP.008 - Infraestrutura I Carga Horária166,
Diário 357428 20212.AGROP.2B AGROP AGROP.008 - Infraestrutura I Carga Horária166,
Diário 357447 20212.AGROP.2C AGROP AGROP.008 - Infraestrutura I Carga Horária166,
Diário 373517 20212.SAGN.4 SAGN AGR. AGR.205 – Maquinas e Motores 45
Diário 373800 20212.SAGN.4 SAGN AGR. AGR.205 – Maquinas e Motores45
Total Horas: 590,

2- ATIVIDADE DE APOIO AO ENSINO

2.10 - Orientação de alunos bolsistas/voluntários de iniciação pesquisa e/ou extensão

Orientação dos estudantes Luiz Folador Neto e Sara ElayneBabilonReckelprojeto de pesquisa 'PJ00006285 - INFLUENCIA DAS CONDIÇÕES AMBIENTAIS NA QUALIDADE DE APLICAÇÃO DE AGROQUÍMICOS NA CULTURA DO FEIJOEIRO'.

2.11 - Orientação de estágio curricular (obrigatório ou não)

Orientação de estagio de estudantes de: Abner Benicio Silva 20191AGROP0682, Amanda Vitoria Carmo Barrena de Souza 20191AGROP0348, Eleonora Nunes Carvalho 20191AGROP0640, Guilherme Joel Figueiredo Santana 20191 MAIEM0144, Iago Henrique de Jesus Silva Santos 20191MAIEM0012, Jhulian Costa Novaes 20171 MAIEM0298, Lainy Kapiche Brito 20191AGROP0402, Luan Nascimento de Souza, 20191AGROP0070, Maria Antônia Cordeiro Vieira 20191AGROP0160, Maria Eduarda Alves de Oliveira 20191AGROP0488 e Melayne Gonçalves de Rezende Arêas 20191AGROP0968 .

2.20 - Cumprimento dos prazos estabelecidos para atividades didático-pedagógicas

[x] 75% a 100% [ ] 50 a 74% [ ] menor que 50%

2.21 - Atendimento e participação em reuniões de cunho pedagógico/administrativo -

[x] 75% a 100% [ ] 50 a 74% [] menor que 50%

formação

3 - ATIVIDADES DE PESQUISA E INOVAÇÃO TECNOLÓGICA

3.2 - Coordenação de projetos de pesquisa com captação de recursos do Ifes

Coordenador do Projeto de pesquisa PICT 2021 Intitulado:'PJ00006285 - INFLUENCIA DAS CONDIÇÕES AMBIENTAIS NA QUALIDADE DE APLICAÇÃO DE AGROQUÍMICOS NA CULTURA DO FEIJOEIRO'

3.9 - Artigo em periódico indexado internacional padrão Capes

3.9.5 - Qualis B3

Spray Deposition on Watermelon Crop in Aerial and Ground Application, Journal of Agricultural Science; Vol. 14, No. 3; 2022 ISSN 1916-9752 E-ISSN 1916-9760 Published by Canadian Center of Science and Education

3.9.7 - Qualis B5

Effect of Electrostatic Spraying on Simulated Fungicide Deposition in Papaya Fruits

IOSR Journal of Engineering (IOSRJEN) www.iosrjen.org ISSN (e): 2250-3021, ISSN (p): 2278-8719 Vol. 12, Issue 3, March. 2022, || Series -I || PP 54-58

4 - ATIVIDADES DE EXTENSÃO

4.9 - Participação como docente em cursos de extensão (a cada 6 horas)

4.10 - Coordenação de cursos de extensão

5- ATIVIDADES ADMINISTRATIVAS

6 – OUTROS

As aulas foram ofertadas no formato de APNP e Presenciais, sendo que o projeto de pesquisa também se deu nesse formato. As aulas do Curso FIC estão sendo dadas totalmente no formato Presencial. As aulas relativas aos diários NÚMEROS: 357409, 357428, 357447, 373517 e 373800 de 2021/2 foram todas, planejadas com uma carga horária maior que a especificada no PIT 2021/1 (média maior semanal de 10 horas), uma vez que por ser no formato ensino híbrido e práticas presencias demandaram de maior tempo semanal, tanto para seu planejamento, preparo e postagens na plataforma Moodle, bem como para ser desenvolvidas em sala de aula. Com relação ao atendimento dos estudantes, este se deu em sua maioria via plataforma do Watsapp e do Moodle (via mensagens escritas e de textos) e também de forma presencial.

Data: 08/06/2022

Assinatura Docente

____

Assinatura do Coordenador

MINISTÉRIO DA EDUCAÇÃO

INSTITUTO FEDERAL DO ESPÍRITO SANTO

CAMPUS SANTA TERESA

Rodovia ES-080, Km 93 – São João de Petrópolis – 29660-000 – Santa Teresa – ES

27 3259-7878

DECLARAÇÃO

Declaramos que o servidor **ÉLCIO DAS GRAÇA LACERDA,** Professor de Ensino Básico, Técnico e Tecnológico, lotado neste campus, participou das reuniões para as quais foi convocado e cumpriu os prazos exigidos para os encaminhamentos das atividades didático-pedagógicas, durante o semestre 2021/2, conforme o constante dos documentos institucionais e legislação específica, obtendo os seguintes percentuais:

- Cumprimento dos prazos estabelecidos para atividades didático-pedagógicas	Percentual: de 75% a 100%
- Atendimento e participação em reuniões de cunho pedagógico/administrativo	Percentual: de 75% a 100%

Em virtude da pandemia de Covid-19, que implicou na suspensão das atividades pedagógicas presenciais em 17 de março de 2020, houve atraso no cumprimento dos anos letivos de 2020 e 2021. Em decorrência disso, não foram realizadas as Avaliações Docentes por parte do corpo estudantil.

Santa Teresa-ES, 27 de abril de 2022.

ADRIANO GOLDNER COSTA:10215692756

Assinado de forma digital por ADRIANO GOLDNER COSTA:10215692756
Dados: 2022.04.27 07:13:26 -03'00'

Adriano Goldner Costa
Coordenador Geral de Ensino
Port. nº 2150, de 01.12.2021

INSTITUTO FEDERAL
ESPÍRITO SANTO

CAMPUS SANTA TERESA
GERÊNCIA DE GESTÃO EDUCACIONAL
Listagem de Diários dos Professores

Filtros Utilizados para Gerar este Relatório:

Institui ção: Campus Santa Teresa
Professor: Elcio das Graça Lacerda (881.208.057-04)(Campus Santa Teresa)
Ano Letivo: 2021
Per. Letivo: 1

Departamento: Coordenadoria Geral de Ensino

Professor	Diário	Turma	Curso	Comp. Curricular	CH
Elcio das Graça Lacerda (881.208.057-	357409	20211.AGROP.2A	AGROP	AGROP.008 - Infraestrutura I	166,
Elcio das Graça Lacerda (881.208.057-	357428	20211.AGROP.2B	AGROP	AGROP.008 - Infraestrutura I	166,
Elcio das Graça Lacerda (881.208.057-	357447	20211.AGROP.2C	AGROP	AGROP.008 - Infraestrutura I	166,
Elcio das Graça Lacerda (881.208.057-	358027	20211.SAGN.5	SAGN	AGR.212 - Mecanização Agrícola	45
Elcio das Graça Lacerda (881.208.057-	358065	20211.SAGN.5	SAGN	AGR.212 - Mecanização Agrícola	45
				Total Horas:	590,

CAMPUS SANTA TERESA
GERÊNCIA DE GESTÃO EDUCACIONAL
Listagem de Diários dos Professores

INSTITUTO FEDERAL
ESPÍRITO SANTO

Filtros Utilizados para Gerar este Relatório:

Instituição: Campus Santa Teresa
Professor: Elcio das Graça Lacerda (881.208.057-04)(Campus Santa Teresa)
Ano Letivo: 2021
Per. Letivo: 2

Departamento: Coordenadoria Geral de Ensino

Professor	Diário	Turma	Curso	Comp. Curricular	CH
Elcio das Graça Lacerda (881.208.057-	373517	20212.SAGN.4	SAGN	AGR.205 - Máquinas e Motores	45
Elcio das Graça Lacerda (881.208.057-	373800	20212.SAGN.4	SAGN	AGR.205 - Máquinas e Motores	45
				Total Horas:	90

INSTITUTO FEDERAL
Espírito Santo

SISTEMA INTEGRADO DE GERENCIAMENTO DA PESQUISA DO IFES

Página Inicial: Sistema | Site   Acesso como Pesquisador   Bem Vindo Elcio (Sair) Meus Dados

Minhas Orientações

Projeto: PJ00006285 - INFLUENCIA DAS CONDIÇÕES AMBIENTAIS NA QUALIDADE DE APLICAÇÃO DE AGROQUÍMICOS NA CULTURA DO FEIJOEIRO   Enviar Arquivos

Plano de Trabalho: PT00010134 - INFLUENCIA DAS CONDIÇÕES AMBIENTAIS NA QUALIDADE DE APLICAÇÃO DE AGROQUÍMICOS NA CULTURA DO FEIJOEIRO   Apresentar na JIC

	Pesquisador	Elcio das Graças Lacerda	Apresentação na JIC	Relatório Final: Não enviado
BS00005646	Estudante	Sara Elayne Babilon Reckel[Termo de Compromisso]	??	Resumo: Não enviado
04/2021 - Pibic-Jr	Ag. Financiadora	CNPq		Poster: Não enviado
Reitoria	Campus Execução	Santa_Teresa		
Ativo	Início da bolsa	01/08/2021		
	Término da bolsa	31/07/2022		

Projeto: PJ00006285 - INFLUENCIA DAS CONDIÇÕES AMBIENTAIS NA QUALIDADE DE APLICAÇÃO DE AGROQUÍMICOS NA CULTURA DO FEIJOEIRO   Enviar Arquivos

Plano de Trabalho: PT00010135 - QUALIDADE DA APLICAÇÃO DE PRODUTOS AGROQUÍMICOS NO CONTROLE DE PLAGAS E DOENÇAS NA CULTURA DO FEIJOEIRO   Apresentar na JIC

	Pesquisador	Elcio das Graças Lacerda	Apresentação na JIC	Relatório Final: Não enviado
BS00005645	Estudante	Luiz Folador Neto[Termo de Compromisso]	??	Resumo: Não enviado
04/2021 - Pibic-Jr	Ag. Financiadora	CNPq		Poster: Não enviado
Reitoria	Campus Execução	Santa_Teresa		
Ativo	Início da bolsa	01/08/2021		
	Término da bolsa	31/07/2022		

MINISTÉRIO DA EDUCAÇÃO

INSTITUTO FEDERAL DO ESPÍRITO SANTO

CAMPUS SANTA TERESA

Rodovia ES – 080, KM 93 – SÃO JOÃO DE PETRÓPOLIS - 29.660-000 - SANTA TERESA – ES

273259-7878

COORDENADORIA DE RELAÇÕES INSTITUCIONAIS E EXTENSÃO COMUNITÁRIA (REC)

DECLARAÇÃO DE ORIENTAÇÃO DE ESTÁGIO

Declaração nº: **04/2022**

Declaramos que o (a) professor(a**) Élcio das Graça Lacerda,** Matrícula Siape n° 6050098, orienta/orientou o estágio dos (as) alunos (as) listados abaixo, conforme dados da tabela:

Matrícula	Aluno(a)	Período	Tipo de Estágio
20191AGROP0682	Abner Benicio Silva	13/10/2021 a 15/01/2022	Obrigatório
20191AGROP0348	Amanda Vitoria Carmo Barrena de Souza	13/10/2021 a 15/01/2022	Obrigatório
20191AGROP0640	Eleonora Nunes Carvalho	13/10/2021 a 23/01/2022	Obrigatório
20191MAIEM0144	Guilherme Joel Figueiredo Santana	13/10/2021 a 22/12/2022	Obrigatório
20191MAIEM0012	Iago Henrique de Jesus Silva Santos	13/10/2021 a 22/12/2022	Obrigatório
20171MAIEM0298	Jhulian Costa Novaes	13/10/2021 a 22/12/2022	Obrigatório
20191AGROP0402	Lainy Kapiche Brito	13/10/2021 a 15/01/2022	Obrigatório
20191AGROP0070	Luan Nascimento de Souza	13/10/2021 a 15/01/2022	Obrigatório
20191AGROP0160	Maria Antônia Cordeiro Vieira	13/10/2021 a 15/01/2022	Obrigatório
20191AGROP0488	Maria Eduarda Alves de Oliveira	13/10/2021 a 23/01/2022	Obrigatório
20191AGROP0968	Melayne Gonçalves de Rezende Arêas	13/10/2021 a 28/01/2022	Obrigatório

IFES – Campus Santa Teresa, 16 de Fevereiro de 2022.

Coordenadoria de Relações Institucionais e Extensão Comunitária (REC)

MINISTÉRIO DA EDUCAÇÃO

INSTITUTO FEDERAL DO ESPÍRITO SANTO

CAMPUS SANTA TERESA

Rodovia ES-080, Km 93 – São João de Petrópolis – 29660-000 – Santa Teresa – ES

27 3259-7878

DECLARAÇÃO

Declaramos que o servidor **ÉLCIO DAS GRAÇA LACERDA,** Professor de Ensino Básico, Técnico e Tecnológico, lotado neste campus, participou das reuniões para as quais foi convocado e cumpriu os prazos exigidos para os encaminhamentos das atividades didático-pedagógicas, durante o semestre 2021/2, conforme o constante dos documentos institucionais e legislação específica, obtendo os seguintes percentuais:

- Cumprimento dos prazos estabelecidos para atividades didático-pedagógicas	Percentual: de 75% a 100%
- Atendimento e participação em reuniões de cunho pedagógico/administrativo	Percentual: de 75% a 100%

Em virtude da pandemia de Covid-19, que implicou na suspensão das atividades pedagógicas presenciais em 17 de março de 2020, houve atraso no cumprimento dos anos letivos de 2020 e 2021. Em decorrência disso, não foram realizadas as Avaliações Docentes por parte do corpo estudantil.

Santa Teresa-ES, 27 de abril de 2022.

ADRIANO GOLDNER COSTA:10215692756

Assinado de forma digital por ADRIANO GOLDNER COSTA:10215692756
Dados: 2022.04.27 07:13:26 -03'00'

Adriano Goldner Costa
Coordenador Geral de Ensino
Port. nº 2150, de 01.12.2021

DECLARAÇÃO

Declaramos que o servidor **ÉLCIO DAS GRAÇA LACERDA,** Professor de Ensino Básico, Técnico e Tecnológico, lotado neste campus, participou das reuniões para as quais foi convocado e cumpriu os prazos exigidos para os encaminhamentos das atividades didático-pedagógicas, durante o semestre 2021/2, conforme o constante dos documentos institucionais e legislação específica, obtendo os seguintes percentuais:

- Cumprimento dos prazos estabelecidos para atividades didático-pedagógicas	Percentual: de 75% a 100%
- Atendimento e participação em reuniões de cunho pedagógico/administrativo	Percentual: de 75% a 100%

Em virtude da pandemia de Covid-19, que implicou na suspensão das atividades pedagógicas presenciais em 17 de março de 2020, houve atraso no cumprimento dos anos letivos de 2020 e 2021. Em decorrência disso, não foram realizadas as Avaliações Docentes por parte do corpo estudantil.

Santa Teresa-ES, 27 de abril de 2022.

ADRIANO GOLDNER COSTA:10215692756
Assinado de forma digital por ADRIANO GOLDNER COSTA:10215692756
Dados: 2022.04.27 07:13:26 -03'00'

Adriano Goldner Costa
Coordenador Geral de Ensino
Port. nº 2150, de 01.12.2021

MINISTÉRIO DA EDUCAÇÃO
INSTITUTO FEDERAL DO ESPIRITO SANTO
PRÓ-REITORIA DE PESQUISA E PÓS-GRADUAÇÃO
Avenida Rio Branco, 50 – Santa Lúcia – 29056-264 – Vitória – ES
27 3357-7500

DECLARAÇÃO

Declaramos para os devidos fins que o(a) pesquisador(a) Elcio das Graças Lacerda, está desenvolvendo o projeto de pesquisa 'PJ00006285 - INFLUENCIA DAS CONDIÇÕES AMBIENTAIS NA QUALIDADE DE APLICAÇÃO DE AGROQUÍMICOS NA CULTURA DO FEIJOEIRO', no Instituto Federal de Educação do Espírito Santo, com previsão de execução no período de 01/08/2021 a 31/07/2022, e que o referido projeto se encontra devidamente cadastrado junto ao Sistema Integrado de Gerenciamento da Pesquisa do Ifes (SIGPESq).

Vitória – ES, 18 de dezembro de 2021.

ROBSON CELESTINO MEIRELES
Diretor de Pesquisa
Campus Santa Teresa

Journal of Agricultural Science; Vol. 14, No. 3; 2022
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Spray Deposition on Watermelon Crop in Aerial and Ground Application

Edney Leandro da Vitória[1,2], Diogo de Souza Alves[1], Matheus Torezani Rossi[1], Raphael Gomes Favero[1], Adriano Alves Fernandes[1,2], Marcelo Barreto da Silva[1,2], Ismael Lourenço de Jesus Freitas[3], Tamara Locatelli[3], Sílvio de Jesus Freitas[4], Silvério de Paiva Freitas[4], Silvério de Paiva Freitas Junior[5], Alex Silva Lima[1,6], Alan de Lima Nascimento[6] & Élcio das Graça Lacerda[7]

[1] Postgraduate Program in Tropical Agriculture, Federal University of Espirito Santo, São Mateus, ES, Brazil

[2] Department of Agricultural and Biological Sciences, Federal University of Espirito Santo, São Mateus, ES, Brazil

[3] Integral Educational Center for Rural Education (CEIER), Secretary of Education State of Espirito Santo, Brazil

[4] North Fluminense State University Darcy Ribeiro, Campos dos Goytacazes, RJ, Brazil

[5] Federal University of Cariri, Juazeiro do Norte, CE, Brazil

[6] Federal Institute of Espírito Santo, Campus Montanha, ES, Brazil.

[7] Federal Institute of Espírito Santo, Campus Santa Tereza, ES, Brazil.

Correspondence: Edney Leandro da Vitória, Department of Agricultural and Biological Sciences, São Mateus, ES, Brazil, Tel: 55-27-3312-1786. E-mail: edney.vitoria@ufes.br

Received: December 31, 2021 Accepted: January 30, 2022 Online Published: February 15, 2022

doi:10.5539/jas.v14n3p172 URL: https://doi.org/10.5539/jas.v14n3p172

Abstract

The quality and quantity production of watermelon requires the effective control of pests, diseases, and weeds, which is directly related to spraying techniques. The method of application of phytosanitary products is essential, but, most of the time, emphasis is given mainly to the applied product and little attention to the application technique. The objective of the present study was to characterize the ejected spray in the aerial and terrestrial spraying of watermelon crops, with the use of adjuvants in a liquid solution. The experiment was carried out in two commercial plantations, in an entirely randomized design, employing a 6 × 2 factorial scheme, with six forms of application and two liquid compositions. The droplet spectrum was assessed employing water-sensitive card imaging. Smaller drop sizes and relative amplitudes were produced by aerial applications. In turn, the largest droplet diameters and the lowest percentage of drops smaller than 100 µm were obtained when using air induction flat double-jet nozzles. The adjuvant did not interfere in the numerical and volumetric median diameters, the relative amplitude, or the volume rate of droplets smaller than 100 µm.

Keywords: spray quality, solution deposition, aerial, terrestrial, *Citrullus lanatus*

1. Introduction

The watermelon (*Citrullus lanatus*) retains the central region of Africa as its center of origin. It is a widely cultivated vegetable in Brazil, especially in semi-arid regions, where the climatic conditions are highly favorable for its cultivation, constituting an essential food for low-income populations (Landau & Silva, 2020).

The quality and quantity production of watermelon requires the effective control of pests, diseases, and weeds, which is directly related to spraying techniques. The most employed method for the protection of watermelon crops consists of terrestrial application using backpack sprayer or tractorized hydraulic sprayers (Emmanuel & Oludele, 2019). Nevertheless, the operational advantages described by aerial spraying have caused a considerable increase in this form of application, although further research is required (Zhang et al., 2020; Liu et al., 2020).

The method of application of phytosanitary products is essential, but, most of the time, emphasis is given mainly to the applied product and little attention to the application technique. Knowledge of the employed product is not enough. Comprehension of the technology of agricultural pesticide application is fundamental. Furthermore, it is necessary to ensure that the product reaches its target efficiently, minimizing losses (Butts et al., 2021; Penney et al., 2021).

Ensuring that spray droplets exhibit uniform distribution and homogeneous sizes is a major factor which can interfere with pesticide application quality. Therefore, during application, overall caution should be given in order to avoid the production of extremely large or small droplets (Zhang et al., 2020). Large drops generate low surface coverage and drainage; on the other hand, they are less prone to wind displacement. Small droplets, although they enable optimal target coverage, may undergo problems such as drift and evaporation, with consequent risks regarding environmental contamination (Wang et al., 2020; Carvalho et al., 2017; Huang et al., 2011).

Hollow cone spray nozzles, which are similar to rotating atomizers used in agricultural aircrafts and sprinklers, are traditionally employed in the application of fungicides and insecticides, and have as a common characteristic the production, in general, of fine droplets. This attribute provides excellent coverage of the target, being, however, highly susceptible to drift. One way to reduce this problem is by using drift-reducing nozzles, or ones that produce coarse drops but provide a good coverage of the target, such as air induction flat double-jet nozzles (Hunter et al., 2020; Tang et al., 2016; Bueno et al., 2013).

One of the problems described when using air induction nozzles is the fact that some commercial brands do not provide sufficient information regarding the population and the size of the produced droplets, the potential drift risk, and their volumetric distribution (Zhang et al., 2020; Rojo et al., 2019).

The addition of adjuvants to the spray mix can aid in drift reduction. Numerous types of adjuvants, which operate differently, can be found on the market, and their potential characteristics include improved wetting, spreading, adherence, and leaf penetration (Zhang et al., 2021; Vieira et al., 2018), as well as reduced surface tension of the droplets by enhancing leaf coverage (Song et al., 2020; Machado et al., 2019). However, Zhang et al. (2020) reported that the addition of adjuvants can alter application performance, and may lead to positive or negative effects regarding product deposition on the target.

The biological efficacy of a phytosanitary treatment can be better evaluated if an analysis of the droplet population is performed following application. One of the tools employed for this assessment is the use of artificial targets, such as water-sensitive cards (Alves et al., 2017). When properly handled, these cards are valuable tools for determining the quality of sprays, particularly in aerial rotating atomizer applications, which do not allow for easy laboratory assessments of the drop spectrum, employing laser droplet analysis equipment, for example.

Therefore, in order to ascertain the quality of a pesticide spray application, it is necessary to evaluate the droplet spectrum. The objective of the present study was to assess the spectrum of drops produced in the aerial and terrestrial spraying of a watermelon plantation, varying the spray nozzles and the composition of the application solution under different operating conditions, given there is little information available in literature regarding the use of phytosanitary products in this crop.

2. Method

The experiment was conducted at the experimental farm Aeroverde Group, located in the municipality of Aracruz (19°49′11″ S and 40°16′27″ W; at an altitude of 100 m) in the State of Espirito Santo, Brazil. The laboratory analyses were carried out at the Laboratory of Mechanization and Application of Agricultural Defensives of the Northern University Center of Espirito Santo, at the Federal University of Esprito Santo, in São Mateus-ES, Brazil

The assessments were carried out in two areas, irrigated by drip irrigation, corresponding to two applications: the first on July 1, 2020, in Area 1; and the second on August 6, 2020, in Area 2, both of approximately 8.0 ha. During the years prior to the survey, the areas underwent watermelon and bean cultivation. The purpose of evaluating two distinct areas was to verify if the results exhibited similar tendencies with respect to the studied characteristics (droplet size spectrum), under different field conditions (mainly environmental conditions).

The employed cultivation system consisted of conventional planting, cultivated with hybrid watermelons using a 100-day cycle. Planting was carried out on March 19, 2020, in Area 1, and on April 15, 2020, in Area 2, by mechanized sowing, with 2.0 m × 2.0 m spacing and 0.02 m planting depths. All of the recommended cultural practices were carried out.

The experimental design was completely randomized, in a 6 × 2 factorial scheme, with five repetitions, composed of six forms of application and two solution compositions. The means of application corresponded to the combination of the 'type of spray' (aerial and terrestrial) and the 'application volume', as described in Table 1.

Table 1. Description of the experimental treatments

Description	Abbreviation
Terrestrial application using double flat spray nozzles (AITTJ60-1102VP), 200 kPa of pressure, 150 L ha^{-1} of solution volume, with and without adjuvant	T 150 IA
Terrestrial application using double flat spray nozzles (AITTJ60-11025VP), 500 kPa of pressure, 300 L ha^{-1} of solution volume, with and without adjuvant	T 300 IA
Terrestrial application using hollow cone spray nozzles (TX-VK10), 300 kPa of pressure, 150 L ha^{-1} of solution volume, with and without adjuvant	T 150 V
Terrestrial application using hollow cone spray nozzles (TX-VK18), 400 kPa of pressure, 300 L ha^{-1} of solution volume, with and without adjuvant	T 300 V
Aerial application using a Micronair AU500 rotating atomizer, 200 kPa of pressure, 12 L ha^{-1} of solution volume, with and without adjuvant	A 12
Aerial application using a Micronair AU500 rotating atomizer, 200 kPa of pressure, 25 L ha^{-1} of solution volume, with and without adjuvant	A 25

In the aerial applications, rotating screen atomizers were employed as a drop-breaking system, varying the position of the variable restriction unit (VRU) of the atomizer in order to obtain the assessed volumes.

The application solution was composed of water and water plus the adjuvant (0.5% v/v Phosphatidylcholine and propionic acid Li700®). According to the manufacturer, the adjuvant is non-ionic, reduces surface tension, and is anti-drift.

In the terrestrial applications, a constant-pressure (CO_2) costal sprayer was employed, equipped with a bar containing six nozzles that were spaced apart by 0.50 m, and 0.50 m in relation to the culture, retaining an average application velocity of 1.2 m s^{-1}. The total area of the experimental units was 70.0 m² (7.0 m wide and 10 m long), which were separated by a longitudinal distance of 10.0 m. In order to avoid the border effect, two lines on each side of the plot and 1.0 m from each end were discarded.

During the aerial applications, an Ipanema 202-A agricultural aircraft, supplied with eight Micronair AU 5000 rotating screen atomizers, was utilized. The flight height was 3.0 m in relation to the culture, at an application speed of 180 km h^{-1}, and the atomizer blades were placed at an angle of 45°. The size of the plots was 20,000 m^2, corresponding to 250.0 m in length and 80.0 m in width, which is equivalent to five 16-meter strides of the aircraft. Following application, a lateral distance of 50.0 m between each plot was established. The worked area corresponded to 2,000 m^2, of which 15.0 m of each side and 100.0 m of each end were discarded.

The sprayings were carried out perpendicularly to the wind direction, and the environmental conditions of the two assays were distinct. The experiment took place in July and august of 2020, the climatic conditions monitored and recorded by means of a meteorological station (Sigma Sensors®, model EMI-RX-500). In addition to being monitored at the time of the applications, the climatic conditions were monitored in the days and hours preceding the applications in order to standardize them, considering as appropriate ranges the temperatures not exceeding 30 °C, relative humidity between 55 and 80% and speed 0.5 and 2.5 m s^{-1}.

The droplet size spectrum were evaluated by the analysis of the water-sensitive cards, which retained dimensions of 76 × 26 mm. Before spraying, four cards were randomly placed within the worked area of each plot, all suspended by a wooden rod above the plant canopy, positioned horizontally and directed upwards, without leaf interference.

The quantification and characterization of the impacts on each water-sensitive paper label were performed immediately after the application of each treatment and drying of the labels using a wireless DropScope system, composed of application programs and a digital wireless microscope with digital image sensor with more than 2500 dpi. This allows him to estimate partially overlapping drops from approximately 35 µm. The following parameters were evaluated: mean volume diameter ($Dv_{0.5}$, µm), numerical median diameter (NMD, µm), relative amplitude (RA) and percentage of the applied volume of wich the droplets have less than 100 µm in diameter (Dv < 100).

Initially, the droplet size spectrum data were subjected to the Kolmogorov-smirnov normality and Levene variance homogeneity tests. Afterward, variance analysis (ANOVA) was performed, and, when a significant difference was verified, the means of the studied characteristics were compared using the Tukey test. The analyses were carried out with the aid of the R software (R Code, 2020).

3. Results

When analyzing the $Dv_{0.5}$ in the first application performed in Area 01, the interaction between the 'forms and volumes of application' and 'adjuvant' factors was not significant, indicating independence of the factors. Regarding the NMD variable, a significant interaction between the factors was observed, inferring dependence between them (Table 2).

Table 2. Volumetric median diameter ($Dv_{0.5}$) and numerical median diameter (NMD) of the sprayed droplets after the first aerial and terrestrial application onto the watermelon culture, with and without adjuvant addition to the spray solution

Forms and volumes of application (L ha^{-1})	$Dv_{0.5}$ (µm)			NMD (µm)		
	Adjuvant		Mean	Adjuvant		Mean
	Without	With		Without	With	
A 12	105	103	104 A	80 Aa	78 Aa	79
A 25	136	109	123 A	74 Aba	74 Aa	74
T 150 H	156	150	153 AB	100 ABCa	96 Aba	98
T 300 H	181	179	180 B	94 ABCa	90 Aba	92
T 150 AI	444	440	442 C	109 Ca	143 Cb	126
T 300 AI	470	473	472 C	106 BCa	109 Ba	108
Mean	249	242		94	98	
	VC = 16.14%			VC = 13.21%		
	$F_F = 140.07$**; $F_A = 0.13^{ns}$; $F_{FxA} = 0.21^{ns}$			$F_F = 26.09$**; $F_A = 2.14^{ns}$; $F_{FxA} = 3.88^{ns}$		

Note. H: hollow cone spray nozzle; AI: double air induction spray nozzle; VC: variation coefficient; F_F: calculated F value regarding the 'form of application' factor; F_A: calculated F value regarding the 'adjuvant' factor; F_{FxA}: calculated F factor regarding the interaction between the 'form of application' and the 'adjuvant' factors. Means followed by the same uppercased letter in a column, and lowercased letters in a row, do not differ between each other at a 5% level of significance by the Tukey test. ** significant at 0.01; ^{ns} not significant.

Regarding the RA and '< 100' variables, no significant interaction between the assessed factors was observed, indicating independence between them (Table 3).

Table 3. Relative amplitude (RA) and percentage of the sprayed volume composed of droplets with diameters inferior to 100 µm (< 100) after the first aerial and terrestrial application onto the watermelon culture, with and without adjuvant addition to the spray solution

Forms and volumes of application (L ha^{-1})	RA			< 100		
	Adjuvant		Mean	Adjuvant		Mean
	Without	With		With	Without	
A 12	0.843	0.803	0.823 A	48.37	47.95	48.16 D
A 25	1.090	1.070	1.080 B	24.79	35.73	30.26 C
T 150 H	0.930	1.003	0.967 AB	11.30	12.22	11.76 B
T 300 H	1.200	1.161	1.181 B	12.90	12.07	12.49 B
T 150 AI	1.231	2.022	1.627B	1.57	0.73	1.15 A
T 300 AI	1.221	1.082	1.152B	1.70	1.56	1.63 A
Mean	1.086	1.190		16.77	18.38	
	VC = 17.77%			VC = 28.40%		
	$F_F = 5.05$**; $F_A = 2.12^{ns}$; $F_{FxA} = 0.93^{ns}$			$F_F = 90.32$**; $F_A = 1.09^{ns}$; $F_{FxA} = 1.80^{ns}$		

Note. H: hollow cone spray nozzle; AI: double air induction spray nozzle; VC: variation coefficient; F_F: calculated F value regarding the 'form of application' factor; F_A: calculated F value regarding the 'adjuvant' factor; F_{FxA}: calculated F factor regarding the interaction between the 'form of application' and the 'adjuvant' factors. Means followed by the same uppercased letter in a column, and lowercased letters in a row, do not differ between each other at a 5% level of significance by the Tukey test. ** significant at 0.01; ^{ns} not significant.

In the second application (Area 2), the interaction between the 'forms and volumes of application' and 'adjuvant' factors was not significant, regarding both the $Dv_{0.5}$ and the NMD parameters. With respect to the two variables, smaller droplet sizes were obtained when using the rotating atomizers with volumes of 12 and 25 L ha^{-1} of solution. In contrast, the highest droplet size values were produced when using the double flat air induction nozzles, with volumes of 150 and 300 L ha^{-1} of solution (Table 4).

Table 4. Volumetric median diameter ($Dv_{0.5}$) and numeric median diameter (NMD) of the sprayed droplets after the second aerial and terrestrial application onto the watermelon culture, with and without adjuvant addition to the spray solution

Forms and volumes of application (L ha^{-1})	$Dv_{0.5}$ (μm)			NMD (μm)		
	Adjuvant		Mean	Adjuvant		Mean
	Without	With		With	Without	
A 12	108	96	102 A	70	60	65 A
A 25	120	121	121 AB	85	74	80 A
T 150 H	165	174	170 BC	106	100	103 B
T 300 H	171	200	186 C	100	103	102 B
T 150 AI	440	433	437 D	121	125	123 C
T 300 AI	418	421	420 D	106	96	101 B
Mean	237	241		98	93	
	VC = 12.40%			VC = 13.23%		
	$F_F = 121.21^{**}$; $F_A = 0.09^{ns}$; $F_{FxA} = 0.91^{ns}$			$F_F = 31.14^{**}$; $F_A = 1.20^{ns}$; $F_{FxA} = 1.01^{ns}$		

Note. H: hollow cone spray nozzle; AI: double air induction spray nozzle; VC: variation coefficient; F_F: calculated F value regarding the 'form of application' factor; F_A: calculated F value regarding the 'adjuvant' factor; F_{FxA}: calculated F factor regarding the interaction between the 'form of application' and the 'adjuvant' factors. Means followed by the same uppercased letter in a column, and lowercased letters in a row, do not differ between each other at a 5% level of significance by the Tukey test. ** significant at 0.01; ^{ns} not significant.

Regarding the RA and the '< 100' variables, no significant interaction between the assessed factors was observed, suggesting independence between them. The lowest RA (0.689) was described in the aerial application with 12 L ha^{-1}, indicating optimal droplet production uniformity, differing from all other treatments (Table 5).

Table 5. Relative amplitude (RA) and percentage of the sprayed volume composed of droplets with diameters inferior to 100 μm (< 100) after the second aerial and terrestrial application onto the watermelon culture, with and without adjuvant addition to the spray solution

Forms and volumes of application (L ha^{-1})	RA			< 100		
	Adjuvant		Mean	Adjuvant		Mean
	Without	With		With	Without	
A 12	0.777	0.601	0.689 A	43.70	62.40	53.05 C
A 25	1.045	1.088	1.067 B	28.60	36.61	32.61 B
T 150 H	1.098	1.044	1.071 B	12.21	11.80	12.01 A
T 300 H	1.222	1.111	1.167 B	10.66	7.78	9.22 A
T 150 AI	1.256	1.321	1.289 B	1.61	1.70	1.66 A
T 300 AI	1.138	1.173	1.156 B	2.25	3.23	2.74 A
Mean	1.089	1.056		16.51	20.59	
	VC = 17.00%			VC = 34.43%		
	$F_F = 9.01^{**}$; $F_A = 0.07^{ns}$; $F_{FxA} = 0.30^{ns}$			$F_F = 66.70^{**}$; $F_A = 3.81^{ns}$; $F_{FxA} = 1.90^{ns}$		

Note. H: hollow cone spray nozzle; AI: double air induction spray nozzle; VC: variation coefficient; F_F: calculated F value regarding the 'form of application' factor; F_A: calculated F value regarding the 'adjuvant' factor; F_{FxA}: calculated F factor regarding the interaction between the 'form of application' and the 'adjuvant' factors. Means followed by the same uppercased letter in a column, and lowercased letters in a row, do not differ between each other at a 5% level of significance by the Tukey test. ** significant at 0.01; ^{ns} not significant.

4. Discussion

The aerial application treatments (12 and 25 L ha^{-1}) produced the lowest droplet sizes ($Dv_{0.5}$): 104 and 123 µm, respectively; as well as the lowest NMD, which ranged from 74 to 79 µm. The highest values of $Dv_{0.5}$ (442 and 472 µm) and NMD (126 and 108 µm) were produced by 150 and 300 L ha^{-1} terrestrial applications, using double air induction spray nozzles, as shown in Table 2.

The volumetric diameter of the droplets was not altered by the addition of the adjuvant. Also, it did not interfere with the NMD values, except the 150 L ha^{-1} terrestrial application treatment with the double air induction spray nozzle, in which the use of the adjuvant increased the NMD value.

Zhang et al. (2021) reported that the addition of the phosphatidylcholine + propionic acid adjuvant to the spray solution did not alter the $Dv_{0.5}$ of the drops produced by the hollow cone spray nozzle. However, it caused a 30% reduction in the $Dv_{0.5}$ of the droplets emitted by the flat air induction nozzle.

In a study determining the effect of formulations on spray characteristics, it was established that air induction nozzles are more susceptible to changes in the physical properties of the solution, and their behavior does not always follow that of conventional hydraulic nozzles (Wei et al., 2020; Zhang et al., 2020; Vieira et al., 2018).

The fact that some manufacturers do not provide information regarding droplet size spectrum can be a problem when working with air induction nozzles. According to Vitória et al. (2019), such information is essential for nozzle selection, in order to obtain greater efficiency in target coverage and lower environmental risks.

The droplet set uniformity, or the droplet size variation spectrum, can be expressed by the RA, in which the higher the RA value, the larger the spray droplet size range. According to Vitória et al. (2019), the homogeneous droplet spectrum retains a relative amplitude value that tends to zero. The results of the present study indicate that the lowest RA was verified in the aerial treatment using a solution volume of 12 L ha^{-1} (0.823), and in the terrestrial treatment, with 150 L ha^{-1} of solution (0.967), using hollow cone spray nozzles, inferring greater homogeneity in droplet formation when compared to the venturi system of hydraulic flat double air induction nozzles (Machado et al., 2019; Huang et al., 2011).

Hussain et al. (2019) and Fritz et al. (2011) evaluated the uniformity of the set of droplets produced by aerial systems (hydraulic nozzles, rotating disc atomizers, and electrostatic systems), and also verified the lowest relative amplitude values with the use of atomizers (15 L ha^{-1}) and the electrostatic system (5 L ha^{-1}) in the canopy of a rice culture. The use of high-speed rotating atomizers in agricultural aviation generates a more uniform droplet spectrum (Tang et al., 2016), corroborating with the results described in the present study.

According to Moraes et al. (2019), the estimation of the drift potential of a spray can be evaluated by the percentage of droplets with diameters smaller than 100 µm. There is no standard value indicative of drift risk or safe application. Nevertheless, according to the same authors, volume values below 15% of droplets with diameters smaller than 100 µm are generally better suited for environmentally safe applications.

Therefore, aerial applications with the described droplet spectrum should be carried out under environmental conditions that are favorable for phytosanitary applications in order to reduce drift losses to a minimum, such as air temperatures lower than 30 °C, relative humidity higher than 55%, and wind speeds less than 12 km h^{-1}.

The air induction nozzles can reduce potential drift risks. However, the formation of thick and very thick droplets is possible, resulting in increased drainage of the solution and, consequently, reduced spray efficiency (Alves et al., 2018). Furthermore, according to Madureira et al. (2015) and Chechetto et al. (2013), the use of air induction nozzles can provide a similar performance to that of conventional spraying, as long as the spray operator receives information regarding how to initially select the nozzle and how to improve its performance.

No significant difference between the presence and absence of the adjuvant in the spray solution was observed regarding relative amplitude values and the percentage of droplets smaller than 100 µm. A laboratory study carried out employing TT 11002 and TTI 11002 nozzles, with the addition of the phosphatidylcholine + propionic acid adjuvant to the spray liquid, also showed no alteration in relative amplitude values (Alves et al., 2018).

When evaluating droplet sizes using single, low-drift, and air induction hydraulic flat spray nozzles, with the same nominal flow rate, Hunter et al. (2020), Bueno et al. (2013) and et al. (2011) also reported that the air induction nozzles produced larger droplet sizes and retained lower propensity to drift, which corroborates with the results obtained in the present study.

Adjuvants with surfactant properties, such as phosphatidylcholine + propionic acid, have the ability to reduce the surface tension of aqueous solutions applied to a crop, improving leaf adherence (Alves et al., 2018)). This property can lead to a decrease in droplet size; however, the magnitude of this process is not large and varies according to the employed nozzle (Laio et al., 2015). This fact may explain the non-alteration of the volumetric and numerical median diameters with the addition of the adjuvant to the spray solution, observed in the present study.

Regarding the nozzles that operate with hydraulic pressure, the production of significantly uneven drops has been described, which hampers adequate target coverage. The development of technologies that produce more uniform drops is required in order to reduce the number of extremely small or large droplets (Vitória et al., 2019). The adoption of spray equipment that employs rotating atomizers as a drop-breaking system is an option.

The aerial application using 12 L ha^{-1} exhibited the largest percentage of spray droplets smaller than 100 μm, equivalent to 53.05%, differing from the other treatments. This type of droplet spectrum is highly susceptible to drift risk. It is noteworthy that, according to necessity, one can increase the size of the generated droplets by simply changing the angle of the rotating atomizer blades. There are also commercial rotating atomizers that contain specific devices to increase droplet size.

The use of the adjuvant did not significantly interfere with the relative amplitude values and the percentage of droplets smaller than 100 μm. Most of the adjuvants that retain spreader functions, found on the market, have surface tension-reducing properties in their composition, which alter the droplet size. However, the magnitude of this process is not very large and varies according to the employed spraying system.

According to Zhang et at. (2021), Machado et al. (2019) and Madureira et al. (2015), the addition of adjuvants can alter application performance. Therefore, the origin of these products and the implications of their use must be known before acquisition and use.

5. Conclusions

Rotating atomizers provide larger droplet sizes, while when using double air induction spray nozzles, the sizes are smaller. The diameter of the volumetric median, the relative amplitude, and the percentage of droplets smaller than 100 μm are not altered by adjuvant addition to the spray solution. The pressure regulation and the two solution volumes (12 and 25 L ha^{-1}), employed in the aerial application, produced the lowest relative amplitude of the droplet spectrum. However, both volumes resulted in a higher percentage of droplets that were susceptible to drift risk (smaller than 100 μm), when subjected to the adopted pressure.

References

Alves, G. S., Kruger, G. R., & Cunha J. P. A. R. (2018). Spray drift and droplet spectrum from dicamba sprayed alone or mixed with adjuvants using air-induction nozzles. *Pesquisa Agropecuária Brasileira, 53*(6), 693-702. https://doi.org/10.1590/S0100-204X2018000600005

Alves, G. S., Kruger, G. R., Cunha J. P. A. R., Santana, D. G., Pinto, L. A. T., & Guimarães, F. (2017). Dicamba Spray Drift as Influenced by Wind Speed and Nozzle Type. *Weed Technology, 31*(5), 724-731. https://doi.org/10.1017/wet.2017.61

Bueno, M. R., Cunha, J. P. A. R., & Alves, G. S. (2013). Spray liquid deposition in aerial and ground pesticide application in potato crop. *Engenharia Agricola, 33*(6), 1210-1222. https://doi.org/10.1590/S0100-69162013000600014

Butts, T. R., Barber, L. T., Norsworthy, J. K., & Davis, J. (2021). Survey of ground and aerial herbicide application practices in Arkansas agronomic crops. *Weed Technolohy, 35*(1), 1-11. https://doi.org/10.1017/wet.2020.81

Carvalho, F. K., Chechetto, R. G., Mota, A. A. B., & Antuniassi, U. R. (2017). Characteristics and challenges of pesticide spray applications in Mato Grosso, Brazil. *Outlooks Pest Manage, 28*(1), 4-6. https://doi.org/10.1564/v28_feb_02

Chechetto, R. G., Antuniassi, U. R., Mota, A. A. B., Carvalho, F. K., Silva, A. C. A., & Vilela, C. M. (2013). Influence of spray nozzles and adjuvants in drift reduction potential in wind tunnel. *Semina, 34*(1), 37-46. https://doi.org/10.5433/1679-0359.2013v34n1p37

Emmanuel, O., Oludele, O. E., & Unwabunne, U. M. (2019). Efficiency and economic viability of neem seed oil emulsion and cyper-diforce® insecticides in watermelon production within the Nigerian Southern Guinea Savanna zone. *Journal Crop Protection, 8*(1), 81-101. https://doi.org/10.48048/wjst.2021.9052

Fritz, B. K., Hoffmann, W. C., Bagley, W. E., & Hewitt, A. (2019). Field scale evaluation of spray drift reduction technologies from ground and aerial application systems. *Journal da ASTM Internacional, 8*(5), 1-7. https://doi.org/10.1520/JAI103457

Huang, Y., & Thomson, S. J. (2011). Characterization of in-swath spray deposition for CP-11TT flat-fan nozzles used in low-volume aerial application of crop production and protection materials. *Trans ASABE, 54*(6), 1973-1979. https://doi.org/10.13031/2013.40645

Hunter, J. E., Gannon, T. W., Richardson, R. J., Yelverton, F. H., & Leon, R.G. (2020). Coverage and drift potential associated with nozzle and speed selection for herbicide applications using an unmanned aerial sprayer. *Weed Technology, 34*(2), 235-240. https://doi.org/10.1017/wet.2019.101

Landau, E. C., & Silva, G. A. S. (2020). *Evolution of watermelon production*. Embrapa, Brasília. Retrieved from https://www.alice.cnptia.embrapa.br/bitstream/doc/1122689/1/Cap33-EvolucaoProducaoMelancia.pdf

Penney, A. J., Kandel, Y. R., Viggers, J. N., Robertson, A. E., & Mueller, D. S. (2021). Comparison of aerial and ground sprayer fungicide application technologies on canopy coverage, disease severity, lodging, and yield of corn. *Crop Protection, 139*, 105393. https://doi.org/10.1016/j.cropro.2020.105393

Liao, J., Zang, Y., Zhou, Z., & Luo, X. (2015). Quality evaluation method and optimization of operating parameters in crop aerial spraying technology. *Transactions of the CSAE, 31*, 38-46. https://doi.org/10.11975/j.issn.1002-6819.2015.z2.006

Liu, Y., Ru, Y., Duan, L., & Qu, R. (2020). Model and design of real-time control system for aerial variable spray. *PLoS ONE, 15*, 1-16. https://doi.org/10.1371/journal.pone.0235700

Machado, W. A., Silva, S. M., Carvalho, S. M., & Cunha, J. P. A. R. (2019). Effect of nozzles, application rates, and adjuvants on spray deposition in wheat crops. *Engenharia Agricola, 39*(1), 83-88. https://doi.org/10.1590/1809-4430-Eng.Agric.v39n1p83-88/2019

Madureira, R. P., Raetano, C. G., & Cavalieri, J. D. (2015). Interaction spray nozzle-adjuvant to estimate potential risk of spray drift. *Revista Brasileira de Engenharia Agricola e Ambiental, 19*(2), 180-185. https://doi.org/10.1590/1807-1929/agriambi.v19n2p180-185

Moraes, E. D., Saab, O. J. G. A., Gandolfo, M. A., Marubayashi, R. Y. P., & Gandolfo, U. D. (2019). Potential risk of drift from inclined fan nozzles. *Revista Brasileira de Engenharia Agricola e Ambiental, 23*(3), 229-233. https://doi.org/10.1590/1807-1929/agriambi.v23n3p229-233

R Core Team. (2020). *R: A language and environment for statistical computing. R* Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org

Rojo, B. F. H., Antuniassi, U. R., Castilho, B. R., Teodoro, P. E., & Silva, E. E. (2019). Factors affecting aerial spray drift in the Brazilian Cerrado. *PLoS ONE, 14*(2), 1-10. https://doi.org/10.1371/journal.pone.0212289

Song, R., Shen, G., Liu, Y., Tang, F., Chen, Q., & Sun, P. (2020). Preparation and characterization of an oil-in-water microemulsion of thiamethoxam and acetamiprid without organic solvent for unmanned aerial vehicle spraying. *Colloids Surf A Physicochem Eng Asp, 607*, 125485. https://doi.org/10.1016/j.colsurfa.2020.125485

Tang, Q., Chen, L., Zhang, R., Zhang, B., Yi, T., & Xu, M. (2016). Atomization characteristics of normal flat fan nozzle and air induction nozzle under high speed airflow conditions. *Transactions of the Chinese Society of Agricultural Engineering, 32*(22), 121-128. https://doi.org/10.11975/j.issn.1002-6819.2016.22.017

Vieira, B. C., Alves, G. S., Carvalho, F. K., Cunha, J. P. A.R., Antuniassi, U. R., & Kruger, G. R (2018). Influence of airspeed and adjuvants on droplet size distribution in aerial applications of glyphosate. *Applicate Engeeneier in Agriculture, 34*(3), 507-513. https://doi.org/10.13031/aea.12587

Vitória, E. L., Crause, H. C., Freitas, I. L. J., Locatelli, T., Lacerda, E. G., Valle, J. M., & Silva, M. B. (2019) Droplet Spectrum Produced in Pumpkin Cultures Submitted to Different Forms of Spraying. *Journal Agricuture Science, 11*(14), 57-64. https://doi.org/10.5539/jas.v11n14p56

Zhang, X., & Xiong, L. (2021). Effect of adjuvants on the spray droplet size of pesticide dilute emulsion. *Colloids Surf A Physicochem Eng Asp, 619*, 126557. https://doi.org/10.1016/j.colsurfa.2021.126557

Wang, J., Lan, Y., Wen, S., Hewitt, A. J., Yao, W., & Chen, P. (2020). Meteorological and flight altitude effects on deposition, penetration, and drift in pineapple aerial spraying. *Asia-Pacific Journal of Chemical Engineering, 15*(1), 1-10. https://doi.org/10.1002/apj.2382

Wei, K., Xu, W., Liu, Q., Yang L., & Chen, Z. (2020). Preparation of a Chlorantraniliprole-Thiamethoxam Ultralow-Volume Spray and Application in the Control of Spodoptera frugiperda. *ACS Omega, 5*(30), 19293-19303. https://doi.org/10.1021/acsomega.0c02912

Zhang, H., Zhou, H., Zheng, J., Liao, J., & Hewitt, A. J. (2020). Adjuvant's Influence to Droplet Size Based on Forestry Pests' Prevention with Ground and Air Chemical Application. *Linye Kexue/Sci Silvae Sinicae, 56*(5), 118-129. https://doi.org/10.11707/j.1001-7488.20200514

Zhang, S., Xue, X., Sun, T., Gu, W., Zhang, C., & Peng, B. (2020). Evaluation and comparison of two typical kinds uaas based on the first industry standard of China. *Internacional Agriculture Engenier Journal, 29*(3), 331-340. https://doi.org/10.3390/agronomy11102035

IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 12, Issue 3, March. 2022, || Series -I || PP 54-58

Effect of Electrostatic Spraying on Simulated Fungicide Deposition in Papaya Fruits

Carlos Pettene de Araújo[1], Ismael Lourenço de Jesus Freitas[2], Tamara Locatelli[2], Thales Gomes dos Santos[3],Francisco de Assis Ferreira[3], Élcio das Graça Lacerda[4], Gilson Geraldo Soprani Junior[5], Edney Leandro da Vitória[5]

[1]BIOTROP -Biological and Natural Solutions,Vinhedo-SP, Brazil
[2] Integral Educational Center for Rural Education, Secretary of Education State of Espirito Santo,Brazil
[3]Department of Agricultural and Biological Sciences, Federal University of Espirito Santo, São Mateus-ES Brazil
4Federal Institute of Education, Campus Santa Teresa-ES, Brazl
[5]Postgraduate Program in Tropical Agriculture, Federal University of Espirito Santo, São Mateus-ES Brazil
Received 28March 2022; Accepted 10April 2022

Abstract:
Background: Brazil is the world's second largest producer of papaya, behind Mexico and India, respectively. Among the main consumers of Brazilian fruit are the United States, England, Germany and Portugal. The species Carica papaya is the most cultivated in the world. However, papaya is constantly infested and attacked by diseases and pests.
Materials and Methods: The experiment was carried out in experimental area of papaya, cultivated with the species Carica papaya of the formosa group, belonging to the Experimental Farm of CEUNES / UFES in São Mateus – ES, Brazil.. The experiment was conducted in a 4 x 2 x 2 factorial scheme, with two distances (10, 20, 30 and 40 cm), two faces (exposed face and the back of the fruit near the stem) two spray systems (Electrostatic system connected and off) and four replicates, totaling 64 experimental units. The deposition of the syrup on the exposed face and the back of the fruit near the stem were evaluated
Results: In the evaluation of the efficiency of deposition of the application, considering the side of the fruit, it was verified that the back of the fruit next to the stem, side not exposed to the spray receives a deposition at least 10 times smaller than the exposed side. The higher deposition value presented on the exposed side indicates application inefficiency, in addition it is observed that the deposition decreases with the application distance. The range with the highest application efficiency for the deposition of syrup is 10 to 20 cm of the fruit. There is low deposition of syrup on the unexposed side of the fruit. In the climatic conditions presented in this experiment, the application with electrostatic sprayer is not efficient.
Key Word:Carica Papaya, Application distance, Spray

I. Introduction

Brazil is the world's second largest producer of papaya, behind Mexico and India, respectively. Among the main consumers of Brazilian fruit are the United States, England, Germany and Portugal. The species Carica papaya is the most cultivated worldwide[1]. According to the Confederation of Agriculture and Livestock of Brazil (CNA), Brazilian production is 1.5 million tons, in an area of 32 thousand hectares, which generates productivity close to 50 tons per hectare. In addition to Espirito Santo, Bahia, the largest national supplier, and Rio Grande do Norte stand out in the activity[2].Papaya is constantly infested and attacked by diseases and pests, the most economically important being the Papaya Mosaic, Meleira Virus, Tipping or Damping-off, Powdery Mildew, Smallpox or Pinta Preta, Anthracnose, Mealybugs, Fruit Fly, among others. When papaya is affected by any of these agents, it is necessary to care, due to the damage they can cause, such as a drop in production and quality of the harvested fruits and, consequently, losses[3, 4].

The search for reducing the environmental impacts caused by agriculture, as well as a strong demand for alternatives that allow its sustainability, has been increasingly accentuated. The method of application of pesticides most used today is extremely wasteful, therefore not suitable for the new proposed paradigm[5].

Difficulties are observed in the application of pesticides in the papaya crop, due to its architecture, height and fruit insertion, and it is necessary to seek and improve new technologies already used in other crops, in order to minimize environmental impacts[6]. Among these technologies, the application of pesticides with electrostatic sprays has been highlighted, due to its efficiency of application and deposition.

When spraying in the field, it is expected that the distribution of the application solution will allow the greatest possible uniformity in the plant, however, this is not always possible[7]. Spraying with a reduced droplet diameter provides a better dispersion of the same on the leaf surface, obtaining a greater density of droplets on the target and reducing the volume of spray that will be applied per unit of area. When referring to electrostatic spraying, the smaller the diameter of the droplets, the easier to be loaded, however, drops with reduced size, in the condition of low relative humidity and high temperatures, can cause evaporation[8]. Small droplets are subject to a high risk of drift, as they are more likely to deviate from the application range compared to application with larger droplets[9].

Several studies have demonstrated the advantages of electrostatic spraying. According to Hislop (1988), a 50% reduction in the use of pesticides is possible, maintaining their biological effectiveness in phytosanitary treatments, corroborating the data[10], working in orchards, found an increase in deposition with the electrostatic system of up to 50%, compared to conventional spraying systems. Evaluating the electrostatic application in peppers[11] achieved similar results, using application volumes six times smaller than those used in conventional treatments. [12]found that, depending on the size of the plant, electrostatic spraying can provide an increase in deposition by up to 2.51 times compared to conventional spraying in apple trees.

However, despite the great potential of this sprayer, there are studies carried out with electrostatic spraying that did not improve the application of pesticides, such as those carried out by[13] in the rice crop, which found lower penetration of droplets inside the crop and lower droplet densities, compared to other spraying systems. [14]Evaluated the electrostatic spraying on citrus and found that the electrostatic spraying did not provide an increase in the deposition of the application solution. Therefore, the objective was to evaluate the spraying electrostatic spray, with costal electrostatic sprayer, regarding the efficiency in the deposition of the application solution on papaya fruits.

II. Material And Methods

The experiment was carried out at the Experimental Farm of the North University Center of Espirito Santo, at the Federal University of Espirito Santo, Brazil, latitude 18º40' 25"S, longitude 40º 51' 23" W. The climate of the region is hot and humid, type Aw, with dry season in autumn-winter and rainy season in spring-summer, according to the Köppen classification.. The papaya plants were 17 months old. The soils in the region are predominantly Dystrophic Yellow Argisols, with a medium sandy texture.

The experiment was carried out in a 4 x 2 x 2 factorial scheme, with four distances (0.10, 0.20, 0.30 and 0.40 m), two faces (exposed side and non-exposed side of the fruit) two spraying systems (electrostatic system on and off) and four replications, totaling 64 experimental units (Figure 1).

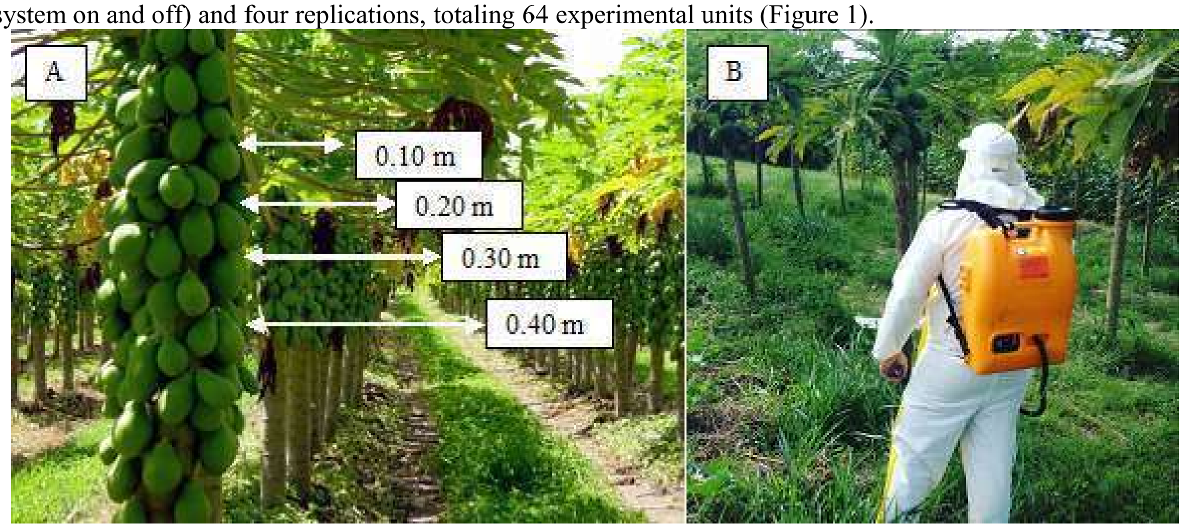

Figure 1. (A) application distances, (B) electrostatic backpack sprayer.

An electrostatic sprayer, *JetBras* brand, with a tank capacity of 18 L was used. This sprayer uses the hydraulic principle for the formation and fractionation of drops, in addition to using the indirect charge induction method for the electrification of drops. For the preparation of the syrup, good quality water and the Blue Brilliant dye were used in the dilution of 3g L^{-1}.

In the field, the equipment flow was adjusted to 0.56 $Lmin^{-1}$ and calibration was carried out to apply a spray volume of 400 $L.ha^{-1}$. In all sprayings, the sprayer motor was set at maximum acceleration, spraying was carried out, considering two methods: 1- Electrostatic system on and 2- Electrostatic system off.Before spraying, the fruits were labeled with polyvinyl chloride (PVC) labels measuring 0.07 m in length and 0.07 cm in height, with an area of 35 cm^2, on the exposed face and on the back of the fruit near the stalk. A sample of the solution was also removed for later calibration of the standard solution in the laboratory. At the time of spraying, environmental conditions were monitored and the air speed was 0.9 m/s, relative humidity of 88% and air temperature between 23.0 and 18.9°C. The sprays were carried out on random fruits, in the direction of the wind, applying to the exposed front of the fruit, the exposed face of the fruit was adopted as the display surface and the back part close to the stem.

The collected labels were placed in plastic bags in a styrofoam box, washed in 25 mL of distilled water and the absorbances determined in the spectrophotometer. Then, the deposition of the dye per unit of area was determined in the LAGRO (Laboratory of Agronomic Analysis) according to the methodology proposed by[15], using the Blue Brilliant dye in the dilution of 3g L^{-1} as a tracer (Figure 2). The data were submitted to analysis of variance by the F test ($p<0.05$) and the means were compared by the Tukey test ($p<0.05$), with the aid of the Assistet statistical software.

Figure 2. Tracer dye deposition analysis from sample preparation to spectrophotometer analysis

III. Result

Table 1 presents the analysis of variance of the syrup deposition data on papaya fruits.

Table 1. Analysis of variance of spray deposition data on papaya fruits as a function of application distance, operating condition and fruit side.

source of variation	medium square	Test F
application distance (D)	7,800	11,324
operating condition (C)	0,604	0,877^{ns}
fruit side (L)	59,903	86,960**
D x C	0,132	0,198^{ns}
D x L	4,111	5,964**
C x L	0,357	0,519^{ns}
D x C x L	0,110	0,161^{ns}
Trataments	6,488	9,419**
Error	0,689	
CV = 69,57%		

**significant at 1% probability level; ^{ns}not significant at the 1% probability level

Table 2 presents the results of the comparisons of the deposition averages of the papaya fruit.

Table 2. Average spray deposition on the papaya fruit side

Side of fruit	Deposition (μL cm^{-2})
exposed side	2,16 a
unexposed side	0,23 b

Means followed by the same letter do not differ from each other at 1% probability by the F test.

Figure 3 shows the behavior of sprayed syrup deposition on the fruit, regardless of the exposed face.

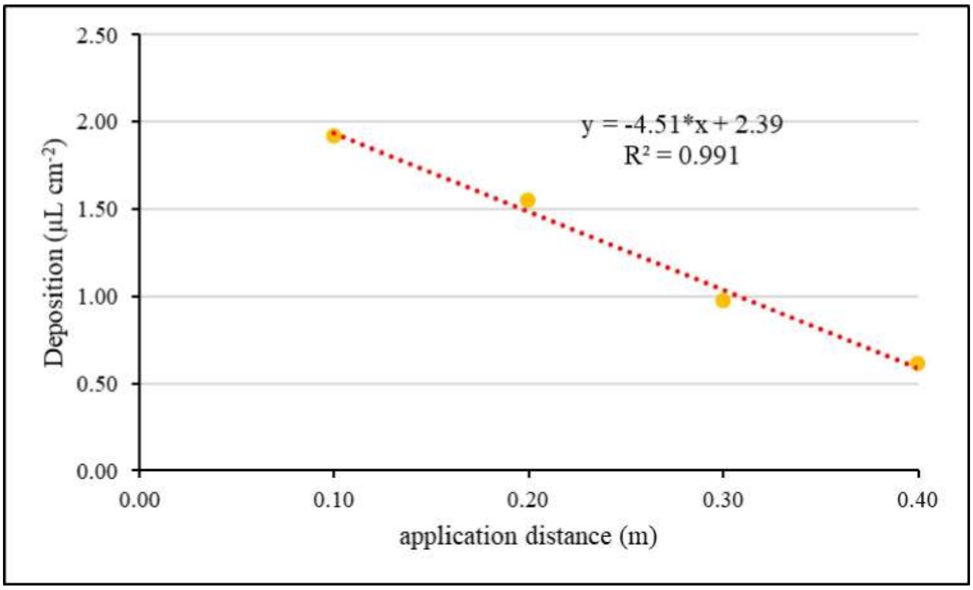

Figure 3. Spray deposition on papaya fruits as a function of application distance.

Table 3 shows the sprayed solution deposition as a function of the application distance and exposed face of the papaya fruit.

Tabela 3. Spray deposition (µL cm^{-2}) on the papaya fruit side as a function of application distance

application distance (m)	Fruit side in relation to spraying	
	exposed side	unexposed side
0,10	3,44 a	0,53 b
0,20	2,75 a	0,22 b
0,30	1,78 a	0,11 b
0,40	0,67 a	0,04 a

Means followed by the same letter on the line do not differ at the 5% level of significance by Tukey's test.

IV. Discussion

The analysis of variance (ANOVA) of the deposition data shows that there was a significant difference in relation to the deposition of syrup on the fruit side alone and in the interaction with the distance (Table 1).

These ANOVA results were noted in part by [7, 10], the first studying deposition on coffee leaves and the second on artificial targets, both in the laboratory. In these works, the efficiency of electrostatic spraying on when compared with the same off was evidenced. The fact that similar results were not observed in this work is due to the influence of weather conditions at the time of application, mainly due to the wind which, although it was within the range suggested by ISO at the time of application, varied considerably in direction. Another factor that must be taken into account is that the application rate favored very fine droplets, susceptible to drift.

In the evaluation of the deposition efficiency of the application, considering the fruit side, it was found that the side not exposed to spraying receives a deposition at least 10 times lower than the exposed side (Table 2).

Figure 3 presents the deposition results as a function of the application distance. It is possible to observe that the greater the distance, the lower the spray deposition.

The highest deposition value presented on the exposed side indicates application inefficiency, in addition, it is observed that deposition decreases with application distance at a rate of 5.4, that is, for every 0.10 of application distance, deposition decreases 5.4 times. Climatic factors at the time of application, the size of droplets produced and the interaction with the application distance (Table 3) are explanations for this difference.

Analyzing the interaction between application distance and fruit side, the same decreasing trend of deposition is observed, that is, greater deposition in the part of the fruit exposed to spraying. This was possibly due to the fact that the electrified drops tend to settle at the closest possible point. Similar results were found by [13,16].

V. Conclusion

According to the results obtained, it is concluded that the best application range for spray deposition is 10 to 20 cm from the fruit. There is no good spray deposition on the unexposed side of the fruit. Application with electrostatic spray is not efficient in the climatic conditions presented in this experiment.

References

[1]. Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA. Disponível em: <https://www.embrapa.br/mandioca-e-fruticultura/cultivos/mamao>. Acess em: 17 jan. 2022.

[2]. Confederação da Agricultura e Pecuária do Brasil – CNA. Disponível em: < http://www.cnabrasil.org.br/noticias/o-municipio-de-linhares-no-espirito-santo-e-modelo-na-producao-de-mamao-no-pais >. Acesso em: 19 set. 2021.

[3]. Faria, A., Noronha, A. D. S., Oliveira, A. A., Oliveira, A., Cardoso, C., Ritzinger, C., Oliveira, J. R. P. A cultura do mamão / Embrapa Mandioca e Fruticultura Tropical. – 3. ed. rev. ampl. – Brasília, DF: Embrapa Informação Tecnológica, 2009. 119 p.: il. – (Coleção Plantar, 65).

[4]. Martins, D. S., de Lima, A. F., Fornazier, M. J., Barcellos, B. D., Queiroz, R. B., Fanton, C. J., Fornazier, D. L. (2016). WHITEFLIES (HEMIPTERA: ALEYRODIDAE) ASSOCIATED WITH PAPAYA (Carica papaya L.). Revista Científica Intelletto, Venda Nova do Imigrante, ES, Brasil v.2, n.1, p.78-86.

[5]. Chaim, A. Pulverização eletrostática: principais processos utilizados para eletrificação de gotas. Jaguariúna: Embrapa Meio Ambiente, 2006. 17p. (Embrapa Meio Ambiente. Documentos, n.57).

[6]. Sasaki, R. S., Teixeira, M. M., Nogueira, L. E., Alvarenga, C. B., Oliveira, M. V. M. Desempenho operacional de um pulverizador costal elétrico. Pesquisa Agropecuária Tropical (Agricultural Research in the Tropics), 43(3), 10-1590, 2013.

[7]. Villalba, J., e E. Hetz. "Deriva de productos agroquímicos-Efecto de las condiciones ambientales." In Tecnología de aplicación de agroquímicos. Argentina: Área de comunicaciones del INTA Alto Valle (2010): 45-54.

[8]. Kirk, i.w. Measurement and prediction of atomization parameters from fi xed-wing aircraft spray nozzles. Transactions of the ASABE, St. Joseph, v.50, p.693-703, 2007.

[9]. Xiongkui, H. et al. Precision orchard sprayer based on automatically infrared target detecting and electrostatic spraying techniques. International Journal of Agricultural and biological engineering, Beijing, v.4, p.35-40, 2011.

[10]. Derksen, r.c. et al. Field evaluation of application v ariables and plant density for bell pepper pest management. Transactions of the ASAE, St. Joseph, v.50, n.6, p.1945-1953, 2007.

[11]. Laryea, G.N.; No, S.Y. (2005) Effect of fan speed and electrostatic charge on deposition of orchard canopy sprays. Atomization and Sprays, Redding, v.15, p.133-144.

[12]. Bayer, T., Costa, I. F., Lenz, G., Zemolin, C., Marques, L. N., & Stefanelo, M. S. (2011). Equipamentos de pulverização aérea e taxas de aplicação de fungicida na cultura do arroz irrigado. Revista Brasileira de Engenharia Agricola e Ambiental-Agriambi, 15(2).

[13]. Magno Júnior, R. G., Teixeira, M. M., Vieira, L. B., Ferreira, L. R., e Alvarenga, C. B. (2011). Desenvolvimento de um dispositivo eletrônico para atração de gotas da aplicação eletrostática em plantas cítricas. Bioscience Journal, 27, 798-804.

[14]. Palladini, L.A. Metodologia para avaliação da deposição em pulverizações. (2000). 111f. Tese (Doutorado em Agronomia) – Universidade Estadual Paulista, Botucatu, SP.

Carlos Pettene de Araújo, et. al. "Effect of electrostatic spraying on simulated fungicide deposition in papaya fruits." *IOSR Journal of Engineering (IOSRJEN),* 12(03), 2022, pp. 54-58.

MINISTÉRIO DA EDUCAÇÃO
INSTITUTO FEDERAL DO ESPÍRITO SANTO
CAMPUS SANTA TERESA
Rodovia ES-080, Km 93 – São João de Petrópolis – 29660-000 – Santa Teresa-ES
27 3259-7878

COORDENADORIA GERAL DE EXTENSÃO

DECLARAÇÃO

Declaro para os devidos fins que o professor **Élcio das Graça Lacerda,** Matrícula SIAPE nº 6050098, coordenou e ministrou o Curso de Formação Continuada "Curso de operação de máquinas pesadas na conservação do solo e da água - Probacias Sul I", cadastrado nessa coordenadoria pelo processo número 23156.002155/2021-56, realizado a partir de 18 de agosto de 2021, computando a carga horária de 50 horas de atividades até a presente data.

Santa Teresa-ES, 20 de dezembro de 2021.

Vilacio Caldara Junior
Coordenador Geral de Extensão
Port. Nº 2310/GR de 15 de dezembro de 202

MINISTÉRIO DA EDUCAÇÃO
INSTITUTO FEDERAL DO ESPÍRITO SANTO
CAMPUS SANTA TERESA
Rodovia ES-080, Km 93 – São João de Petrópolis – 29660-000 – Santa Teresa-ES
27 3259-7878

COORDENADORIA GERAL DE EXTENSÃO

DECLARAÇÃO

Declaro para os devidos fins que o professor **Élcio das Graça Lacerda,** Matrícula SIAPE nº 6050098, coordenou e ministrou o Curso de Formação Continuada "Curso de operação de máquinas pesadas na conservação do solo e da água - Probacias Sul I", cadastrado nessa coordenadoria pelo processo número 23156.002155/2021-56, realizado a partir de 18 de agosto de 2021, computando a carga horária de 50 horas de atividades até a presente data.

Santa Teresa-ES, 20 de dezembro de 2021.

Vilacio Caldara Junior
Coordenador Geral de Extensão
Port. Nº 2310/GR de 15 de dezembro de 202