English Version

Effect of different volumes and adjuvants in the air and ground spraying in the maize culture

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Abstract

The experiment was conducted in the 2007/2008 crop in the city of Carambeí (PR) Brazil, Latitude 24° 55' 04" S, Longitude 50° 05' 50" W. The objective was to evaluate the effect of different spray volumes and spray adjuvants in air and ground application of fungicide in corn. The treatments consisted of application of the chemical fungicide strobilurine (pyraclostrobin) and triazolam (Epoxiconazol) with concentration 133/50 SC at a dose of 0.7 L ha^{-1} (93.1 / 35 i. a), applied at rates of 10 and 20 L ha^{-1} in aerial spraying and 150 L ha^{-1} ground spraying, and adjuvants used were: a) vegetable oil rectified, b) mineral oil patch c) synthetic adjuvant. The main results found were that in the aerial spraying the dose of 20 L ha^{-1} causes drop spectrum with most appropriated characteristics as the volume median diameter, penetration of drops and potential risk of drift, for the application of 10 L ha^{-1}. It can be used an intermediate flow rate (15 L ha^{-1}) as an alternative for application of fungicides on maize. In the spectrum of spray, droplets of larger diameter tend to reach the leaves of the middle and upper third of leaves and lower third receives drops of smaller diameter and lower density per unit area compared to the leaves of thirds higher in the plant.

Key words: Agricultural aviation; drop; fungicide; *Zea mayz* L.

Introduction

Maize is one of the main crops of the Brazilian agriculture. Nowadays, the development of the plants in the plantation is increasingly threatened by the appearance of fungal diseases, specially those considered as 'DEC', as a reference to 'diseases of end of the cycle', which have been receiving increasing attention from researches.

Until half a decade ago, the main control measures of fungal diseases in the crop were based only on the application of preventive products as seed treatment, according to Munkvold e Martinson (1997). They emphasized that, in that year, the chemical control of DECs would be economically viable only for plantations of seed production, popcorn and sweet corn. However, nowadays, the responses of the crop to the treatment by spraying in the canopy as remedy or preventive in function of the alert by the probability of occurrence of infection by climate condition and even by the susceptibility behavior of the hybrid become increasingly expressive. Casa et al. (2006) describe the importance and viability of fungal disease control in the corn crop, emphasizing the effectiveness of the chemical control with the use of fungicide.

The technology of application used to the crop spraying is one of the main factors to the success of the appropriated use of agricultural defensives. One of the main criterions to be considered are the characteristics of the drops generated by the spray, measured in the target, which generally are the leaves

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in the desired height in the plant. As for Faggion (2008), the droplet spectrum of a spray is normally studied by its Volume Mean Diameter (VMD), relative amplitude, among other aspects. To the same author, these evaluations are indispensible in order to achieve the objectives aimed by the application of agrochemicals by spraying.

In the conventional earth spraying performed with fog, usually the volume of fungicide used range from 120 to 160 L ha^{-1}, with rare exceptions of producers who use lower values; by contrast, there are those who believe that the best results of fungicides are achieved with an application of elevated volume of flow, many times superior to 200 L ha^{-1} to corn crops or even higher, according to Jadoski et al. (2009) to other crops, as potato, for instance. In land equipments, the spray nozzle produces fog with droplets with different sizes.

In the case of aerial application, the agricultural aircrafts tend nowadays to be equipped with rotary atomizers, which enable the application of fogs with lower volumes and, with some limits, a larger control of the size of the droplets to be sprayed. In the systems in which are applied low volumes of flow as the case of the aerial spraying, with volumes between 10 and 40 L ha^{-1}, they must be added mandatorily as vehicle products which come from products which come from vegetal oils, mineral oils, or even synthetics, as adjuvants aiming to minimize the evaporation of active ingredients. To Womac (1997), the application of reduced volume of spraying requires droplets with lower diameter aiming at a better spectral coverage of the crop, however, they need to be protected by an adjuvant aiming to maintain their characteristics as droplet, until reach the target and be absorbed.

The objective of the research was to evaluate the effect of different volumes of spraying flow and adjuvants in the aerial and land application of fungicides in the corn crop.

Material and methods

The research was developed in the area of the Fazenda Agibeira in the municipality of Carambeí (PR). The place is located in Latitude 24° 55' 04"S, Longitude 50° 05' 50"W, and altitude of 1020 meters. The average annual rainfall is 1560 mm, and the average annual temperature is 17.6º C. The average monthly temperature and rainfall for October, November, December and January are 18º C, 19º C, 20º C, 21º C and 140, 120, 140 and 160 mm, respectively.

The local soil is classified as a tipic Latossolo Vermelho Distrófico, A clayey texture prominent alic, phase subtropical land with gentle undulating topography. Seeding was performed in direct seeding system over the black oak crop residues dissected twenty days before the sowing.

The corn hybrid P30F53 was sowed on September 30th, 2007 with spacing of 0.80 m between rows, which resulted in a population of approximately 65 thousand plants ha^{-1}. The base fertilization consisted of 300 kg ha^{-1} of NPK formulation 14-34-00 + Zn and it was applied 250 kg ha^{-1} of NPK formulation 36-00-12 in cover 25 days after the plant emergence.

The treatments were composed by the application of the fungicide [OPERA ®] of the chemical group Strobilurin (Pyraclostrobin) and triazolam (epoxiconazole) with concentration and active ingredient (a. i.) 133/50 SC on the dosage of 0.7 L ha^{-1} (93.1/35 a. i.) in formulation suspension/emulsion, followed by adjuvant which were: a) Rectified vegetal oil [Agróleo®], b) Mineral oil patch [OPPA®] and c)synthetic adjuvant composed of salt of fatty alcohol ethoxylate sulfated + alkanolamides of fatty acid [TA35®], used in the flow of 10 and 20 L ha^{-1}, except mineral oil, which due to the difficulty of operation in the moment of the application was not tested in the volume of 20 L ha^{-1}.

The application technology systems used were: a) land in Nov 11th, 2007, with self-propelled sprayer with nozzle AI11002 tip in volume of 150 L ha^{-1} without adjuvant – plants with height of 1.0 m (phenological stage V9); b) area in Dec 15th, 2007 with agricultural aircraft Ipanema (EMB 201A) equipped with rotary atomizers – plants in pre-tasseling, height of 1.75 m (phenological stage VT – tasseling). Table 1 presents the ordinate description of the treatments applied.

The applications were performed in plot with length of 100 cm. The ground spraying was conducted with three bands of bars with height of 25 m and in the aerial spraying it was used five bands (shots) with 16 m of length, in each plot.

Table 1. Composition of the different treatments applied for the evaluation of the control of diseases on the P30F53 corn hybrid, crop 2007/2008, with fungicide formulation Epoxiconazole + Pyraclostrobin (133/50) in Carambeí – PR.

Treatment Nº	Dosage (mL ha^{-1}) c.p.	a.i.*	Type of application	Moment of application	Flow volume (L ha^{-1})	Adjuvant	Dosage (mL ha^{-1} or% v v^{-1})
1	700	93.1/ 35	Ground	V 18	150	------	------
2	700	93.1/ 35	Aerial	VT	10	Vegetal Oil	10%
3	700	93.1/ 35	Aerial	VT	10	Mineral Oil	10%
4	700	93.1/ 35	Aerial	VT	10	Synthetic	30 mL
5	700	93.1/ 35	Aerial	VT	20	Vegetal Oil	10%
6	700	93.1/ 35	Aerial	VT	20	Synthetic	30 mL

** c. p. commertial product, a.i. active ingredient, V18 and VT – Stage of phenological development.*

The atomizers installed in the aircraft were of the type micronair, the regulation was established for the volume of 10 L ha^{-1}, with spectral droplets with Volume Mean Diameter (VMD) of 200 μm considering the recommendations of the manufacturer to the flight speed of 110 miles per hour – mph (approximately 180 km h^{-1}). For the volume of 20 L ha^{-1}, it was maintained the initial regulation in relation to the droplet diameter aiming to obtain possible variation on the characteristics of the droplets.

Before the performance of the spraying five metal rods (considered as repetitions to statistic analysis) were fixed in random points of each plot, with support for the sensitive paper labels used to collect droplets of the flow sprayed fixing its characteristics for later analysis. The samples were collected in the height of 0.50, 1.20 and 1.70 m, aiming to evaluate the penetration of droplets in the heights near the lower, medium and higher thirds of plants, respectively. In the ground application, the droplets were collected only in the height of 0.50 m which represents the medium third of the plant in the moment of application. It was only evaluated the VMD.

Immediately after the spraying the sensitive paper labels were collected and their image captured with scanner using the resolution of 800 DPI, for later evaluation with the software Sprinkler®. To compare the penetration of droplets in the vegetal canopy, the number of drops collected in the medium and lower thirds were compared to the total verified in the top of the crop, considered as 100%. The statistic analysis was composed by analysis of variance and mean comparation test by Tukey test with probability p>0,05.

The spraying time and the microclimate conditions occurring in the period are presented in Table 2.

Results and discussion

The results of each drop sampling are presented in Table 3. The ground application presented value of VMD above 550 μm and caused high frequency of dripping over the surface of the

Table 2. Synthesis of application time of the treatments and local microclimate conditions.

Flight	Hour	Adjuvant treatment	Temperature °C	Wind Km h^{-1}	Air Humidity%
		Aerial application			
1	08:55	T4	23.3	4.1	71.2
2	09:15	T2	24.3	5.3	68.4
3	09:40	T3	25.7	4.4	65.3
4	10:40	T6	26.4	5.8	61.7
5	11:42	T5	27.2	3.4	56.8
		Ground application			
-	09:00	T1	24.5	4.6	66.2

sensitive paper which increased the difficulty to analyze the characteristics of the spectral spraying making it impossible to the software used to analyze the credibility of some characteristics. For this reason, the variables density of drops and potential drift risk were not considered.

The VMD values verified, despite being high, are in the average of the reality practiced in most of the plantations from Parana ground sprayed, according to data verified by Silveira et al. (2006). In this case it cannot be inferred the efficiency concerning the fungal disease control, however, besides the higher risk of dripping and evaporation of the droplet by the larger time of absorption, there is, in accordance to what is reported by Muller (1993), the dilution of the active principle in a higher flow volume and if this characteristic is associated to drops with larger volume, it is possible that in some situations the efficiency of the spraying is committed.

The initial regulation of the atomizer was effected considering the angular velocity of the blades recommended to obtain droplets with VMD of 200 μm in the volume of 10 L ha^{-1}. Although, it was observed that with this regulation the droplets presented VMD lower to 200 μm with values which range from 135 and 190 μm and approximate average of 160 μm. The VMD of 200 μm was achieved when it was used the volume of 20 L ha^{-1}, with the same regulation of the atomizer, and, in this case, the values ranged from 190 and 235 μm. This shows that the regulation to obtain drops with VMD of approximately 200 μm must be performed with flow of 20 L ha^{-1}. This factor is also affected by the velocity of aircraft displacement; however, as the flights usually are performed with velocity close to 110 mph, these results indicate that it is essential that regular tests of atomizer calibration are conducted, to enable the action with a real control of the characteristics of the drops of the sprayed product. These data are in accordance with the discussion presented by Robert et al. (1999) concerning the formation and deposition of droplets in spraying.

The penetration of drops in the corn plant canopy had as the main feature the presence of higher density of drops in the higher third of the plant (1.70 m) with significant reduction to the medium third (1.20 m) and lower (0.50), respectively. This behavior was evidenced for the two volumes and independent on the adjuvant applied (Figure 1 A, B and C). In the case of the lower third the drops which achieved the

Table 3. Volume Mean Diamater (VMD), Coefficient of VMD variation (CVV), Drop density, Potential Drift Risk (PDR)

Treatments	Height (m)	VMD (μm)		CVV%	Density (n°/ cm^2)		PDR (%<=150μm)
T1 (ground)	0.50	558		73.18	-	-	-
T2	0.50	140.77 b	C	18.97	5.20 c	B	60.44
Aerial	1.20	184.75 a	AB	33.78	14.28 b	C	25.95
	1.70	159.78 b	B	32.98	39.78 a	B	42.93
T3	0.50	135.95 b	C	35.43	6.43 c	B	66.41
Aerial	1.20	159.14 a	B	38.71	19.38 b	B	43.46
	1.70	170.16 a	B	28.16	46.92 a	B	35.04
T4	0.50	158.19 b	B	20.68	6.94 c	B	43.42
Aerial	1.20	190.70 a	A	24.05	17.34 b	B	22.90
	1.70	179.17 b	AB	34.68	41.82 a	B	29.15
T5	0.50	198.25 a	A	19.82	8.16 c	AB	19.60
Aerial	1.20	223.45 a	A	24.06	24.48 b	A	13.07
	1.70	234.81 a	A	21.68	52.02 a	A	12.40
T6	0.50	190.23 b	A	18.58	10.20 c	A	23.13
aerial	1.20	234.03 a	A	23.05	26.52 b	A	12.40
	1.70	210.65 b	A	26.15	58.14 a	A	15.52

- Lower case letter compares inside the treatment;

- Upper case letter in column compares all the heights for VMD and compares thirds of the same position in plant to drop densities.

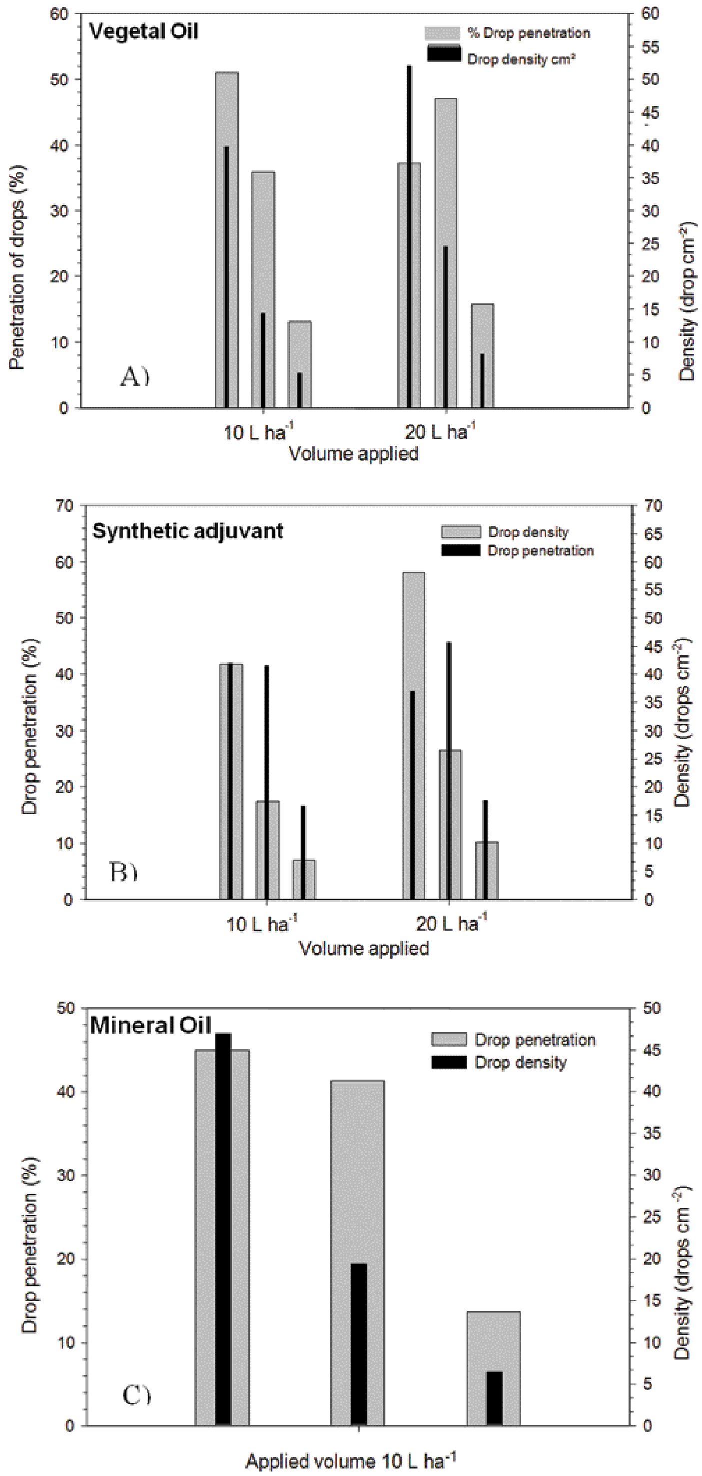

Figure 1. Percentage of drop penetration and drop density to different volumes of application with different adjuvants: a) Vegetal oil, b) Synthetic adjuvant and c) Mineral Oil.

leaves presented always the lower values of VMD. This fact was most evident for the volume of 10 L ha^{-1}, especially since, in this volume, the VMD obtained was also lower regarding the volume of 20 L ha^{-1}.

When relating this behavior with the fungal disease control, especially concerning the lower density in the lower third, it is possible to see that it has low influence in the biological efficiency of the spraying, since, as it is described by Connell et all. (1987), when plants are in an advanced stage of the cycle, the lower leaves are going into senescence and leaves with higher photosynthetic and translocation efficiency are the higher thirds of the plant, especially those located next to the developing ear, and that in this case, should be protected.

To the volumes used, besides the higher VMD, it was verified that the use of flow of 20 L ha^{-1} caused higher drop densities in the highest and medium third of plants in relation to the volume of 10 L ha^{-1}, fact that it was although expected regarding to larger volume applied, must be emphasized as positive and important, since inside some limits, a higher density with considered diameter facilitates the penetration in the leaf parenchyma, reducing losses by evaporation which would occur with higher potential in the case of droplets with higher diameter, characteristics which are clearly detailed by Hollomay (1970) as critic points to leaf absorption.

The application of volume of 10 L ha^{-1} presents performance with lower percentage of penetration of droplets in the medium third of plants with use of mineral oil, also considering that in the lower third the application with synthetic adjuvant tended to better results to this characteristic. In general, the use of adjuvants in the spraying flow had evident effect: it can be clearly observed that the drops maintained their structure until achieve the target. To the aerial spraying this is considered one of the critical points, since the droplets are submitted to conditions which facilitate the drift when they pass in their trajectory by turbulence, as those generated by the vortices of the wing and propeller and by the normal friction with the air in the course until the vegetal canopy. In this case, both the adjuvants present efficiency, and it must also be considered the reduced drop coalescence which can cause increase on the diameter and drip.

According to Salyani et al. (1992), the losses involved between the transport and impact on the deposition of drops contribute to the reduction of the appliance efficiency. The small drops derive to beyond the target area, while the big ones tend to drip from the target surface and fall to the soil.

Conclusions

The adjuvants with synthetic formulation or based in vegetal or mineral oil present satisfactory effect of droplet protection for use in aerial agricultural spraying. However, it may occur variation in drop penetration in the corn canopy.

In the aerial spraying of the corn crop the volume of 20 L ha^{-1} causes droplet spectrum with most appropriate characteristics concerning the volume mean diameter, drop penetration and potential drift risk, regarding the application of 10 L ha^{-1}. The intermediate volume (15 L ha^{-1}) may be a good alternative to the management of the aerial fungicide spray in the corn crop.

In the spraying of the corn crop, the drops with larger diameter tend to achieve the leaves of the medium and higher third and the lower third receives drops with smaller diameter and in lower drop density per unit of area in relation to the leaves of the higher thirds of the plant.

The aerial spraying with use of rotary atomizer must be accompanied of rigorous equipment calibration, since not all the drop characteristics obtained are in accordance with the descriptions of the equipment manual.

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