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EVALUATION OF SPRAY DISTRIPTION FOR LOW PRESSURE EMTF NOZZLES

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ABSTRACT

The full automatic patternometer was used with ultrasonic sensor and compatible software program to measure the spray distribution from different EMTF nozzles under conditions of JKI laboratory in Germany. The goals of present study are measured spray distribution of the EMTF nozzles using the full automatic patternometer single nozzle test, by comparing the distribution profiles of sprays from EMTF nozzles those from standard fan nozzles. As well as investigating to find the optimum combination for EMTF nozzles from the available nozzles in the marketing which may be produced a good uniformity spray distribution. The current investigation research was cared out in the Federal Biological Research Centre for Agriculture and Forestry (JKI), Braunschweig, Germany. The full automatic patternometer was adapted at the optimum air conditions, 20° C air temperature and 80 % relative humidity. Eight external mixing twin fluid nozzles were evaluated in a patternometer single nozzle test to compare spray distribution. Each tip was compared at 60 kPa liquid pressure, parallel to a 150 kPa and 200 kPa air pressure for each. Two levels for nozzle height 50 cm and 70 cm, and co-angling 45° and 60° was treated and studied their effect with the interaction of both nozzles and air pressure on coefficient of variation percent. The results indicated that the minimum CV % values for good spray distribution were 10.6 %, 12.9 % and 14.0 % for EMTF nozzle N8, N3 and N7 at 50 cm nozzle height, 45° co-angling and 200 air pressure respectively. The EMTF nozzle N8 produced the CV % nearly the standard ISO nozzle CV percentages values. The uniformity spray distribution CV percent values for N8 (Lechler FT 5–608 & DG800-04 VK) nozzle at the optimum co-angling 45°were 11.0 % and 12.1% at 50 cm and 70 cm nozzle height respectively.

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As well as, there are non effects of the interaction of air pressures with the all factors on the CV percentage. It may therefore be concluded that the CV % values are more strongly dependant on the combinations of nozzles in the EMTF nozzles, which is highly significant in data.

Key words: Spray distribution, Nozzles. Low pressure

INTRODUCTION

A basic approach to select a spray based on the pattern and other spray characteristics needed, generally, yields good results. The spray selection should be considered early in the design of the system. Although spray considering that the spectrum of standardized sprays currently in existence is so large. A distribution quality test gives the applicator important information about the state of the nozzles on the boom. When it has much more detailed information about spray quality and coverage are required, a dynamic system spraying a tracer (dye) can be used.

Koch and Weisser (1996) clearly demonstrated the importance of dynamic factors; they stated that, spray distribution, measured under static conditions on a patternator, does not represent the pattern achieved in routine dynamic applications. Each specific sprayer configuration defined by nozzle type, spraying height, pressure and speed yields in a specific horizontal dynamic distribution pattern that is unpredictable and shows tangential strips of distinct deposit levels on targets within the sprayed area. Deposition can vary more than 80% and the average actual quantity of deposit was normally much lower than that calculated because of fan geometry and spray losses outside the sprayed area. To avoid misinterpretation, when dose response was investigated, it was necessary to identify the specific dynamic transversal distribution pattern of any sprayer configuration used in tests in order to as sure that dose levels within the sprayed area were known and can be related to target positions below or between nozzle positions. They also stated that the prediction of deposition on targets from distribution measurements on a patternator was an assumption rather than a scientifically proven result.

Hagenvall (1981) concluded that poorer weed control was obtained at greater boom heights despite low measured coefficients of variation. It should be noted that nozzle height can be critical for CV measurement even for flat fan nozzles, with 80° flat fan nozzles tending to give more variable CVs than 110° over standard boom operating heights. Richardson et al. (1985) indicated that the spray pressure can also significantly affect CVs with the same nozzle. The combination of chosen testing height and pressure therefore will affect CVs from each particular nozzle.

Koch (1992), Sinfort and Herbst (1996), Richards et al. (1997) clearly demonstrated that spray distribution on stationary patternator had limited correlation with uniformity of spray deposits on natural targets in the field. The European SPECS project, and other work, shows that coefficients of variation of 7 – 9% achieved on a static patternator under laboratory conditions can translate to values of over 30% under field conditions.

Richardson et al. (2000) showed that a study on aerial herbicide application in New Zealand, there appeared to be little effect on herbicide efficacy of CVs of up to 30%, supporting the study by Enfalt et al, (1997a and 1997b), and possibly even higher. Krishnan et al. (2005) studied the effects of spray boom deflection, wind velocity, and wind direction on spray pattern displacement (SPD) of extended range of 110-0 fan nozzles by using Patternator. Tests were conducted at four nozzle pressures of 139, 208, 313 and 383 kPa. At each pressure, tests were conducted at four wind conditions (including combinations of both cross and head wind), two spray boom deflections of 0.2 and 0.4 m amplitude, and a frequency of 1 Hz. spray boom deflection, wind velocity and wind direction significantly ($P < 0.05$) affected SPD values at 139-, 208-, and 313-kPa nozzle pressure. However, coefficient of variation (C.V., %) values of 8.5% to 13.5% obtained from these tests indicated uniform or acceptable coverage.

Sehsah and Kleisinger (2009) indicated that the spray distribution is improved by increasing nozzle size, pressure and reduces the nozzle height. The type of nozzles is very important parameters which affect the distribution of pattern (C.V.%). The selection of nozzles may be reduced the losses of spray dose and gives good distribution of pattern.

The main objectives of this current study are investigated and evaluate the spray distribution from external mixing twin fluid nozzles by comparing with the standard spray nozzles. To find also the optimal nozzle configuration in the different selected EMTF nozzles combinations.

MATERIAL AND METHODS

The current study was designed to measure the amount of spray distribution from different combinations of external mixing twin fluid nozzles in a Patternator single nozzle test. Initially, the pattern data collection was attempted using the full automatically method, i.e. using the ultrasound sensor with programming mechanical patternator.

Ultrasonic sensor

The programmable ultrasonic sensor Di-Sonic USE46K1500PSKT-TSSL provide high-resolution control of switch point-span settings, compensation for turbulent or unstable target surfaces, and access to extended sensing ranges as well as other parameters. The measured distance range for the above mentioned Ultrasonic sensor is 0 mm to 1500 mm. To simplify the sensor programming procedure, AW software program is available that provides an instant communications link between an RS-232 programmable ultrasonic sensor Di-Sonic and a Windows-based computer. A programmable sensor could be advantageous in a variety of applications, including distance measuring in tight spaces and liquid level control for tubs in Patternator.

Spray liquid measurement level setup

The Ultrasonic sensor Di-Sonic was mounted in rubber elevator which driven by an electric motor. The electric motor was moved from the end of the lift side to the right side in the Patternator. In addition, the eclectic motor controlled by the AW programming system and it was programmed to move over every tube in the Patternator as shown in figure 1. The Ultrasonic sensor was moved over the top of every tube in the Patternator and measured the distance that indicated the spray liquid levels for each tube. These distances of the spray levels for each tube send to the software program to calculate the spray volume for each tube, flow rate, and coefficient of variation CV %. The software AW package from the AW-SYSTEMS GmbH, Am Exer Sr. 10 d-38302 Wolfenbüttel, Germany was used to controlled and measured the relative humidity, liquid pressure, flow-rate for each tube, total flow rate and coefficient of variation percentages (CV %). By computer analysis, from the levels recorded in the patternator tubes for the single candidate nozzle, calculate the distribution for a 3-metre width (i.e. 100 columns) excluding the ends where there is no overlap.

Facilities and measurements

The Patternator consisted of 200 collections Teflon's tubes in two rows and the tube has 25 mm inside diameter and 70 cm height as shown in Figs. 2 and 3. The nozzles were mounted on a X-axis traverse and held in place by a using a clamp assembly. The height of nozzle boom was controlled automatically by the control unit in the full automatic Patternator. Liquid flow to the nozzle was delivered using a pressurized vessel; the GPI Electronic Digital Turbine Meter combine monitored the flow rate. Pressure was monitored immediately upstream of the nozzle body. Manometer pressure was monitored using a 0-1500 kPa, class 3A pressure gauge. All instruments were connected and programmed under AW system. Temperature and humidity were measured using a CMP (Constant Multi Pulse) measurements probe system with data logger. The Tee Jet TT110-3 POM, Tee Jet TT110-5 POM, Lechler LU120-15 POM, Lechler LU120-04 POM, Lechler LU90-04 POM, Lechler AD120-04 POM, Tee Jet XR8003 VS, and Tee Jet DG8004 VK were selected to make the EMTF nozzles and operated at low liquid pressure.

External Mixing Twin Fluid nozzles (EMTF)

The EMTF nozzle was developed in Hohenheim University, Germany as the part of the applicable technique for the biological material (Sehsah, 2005, Sehsah, & Ganzelmeier, 2010, and Sehsah & Herbst, 2010). The principle of the external mixing twin fluid nozzle is the injection of a liquid sheet into air sheet, both produced by tongue nozzles. At the merging line, the high-speed air stream will disintegrate the liquid sheet and produce droplets. With External mixing twin fluid nozzles, the liquid sheet or jet exposed to the atomizing air has little initial momentum and the droplets formed in atomization are entirely dependent on the kinetic energy of the atomizing air to transport them away from the nozzle into the target. The combination of the EMTF nozzle were selected and illustrated in table 1 and Fig. 4.

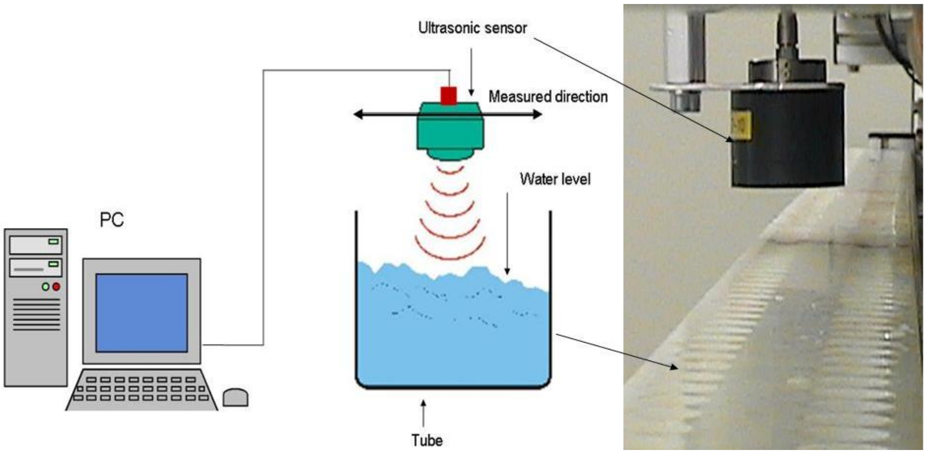
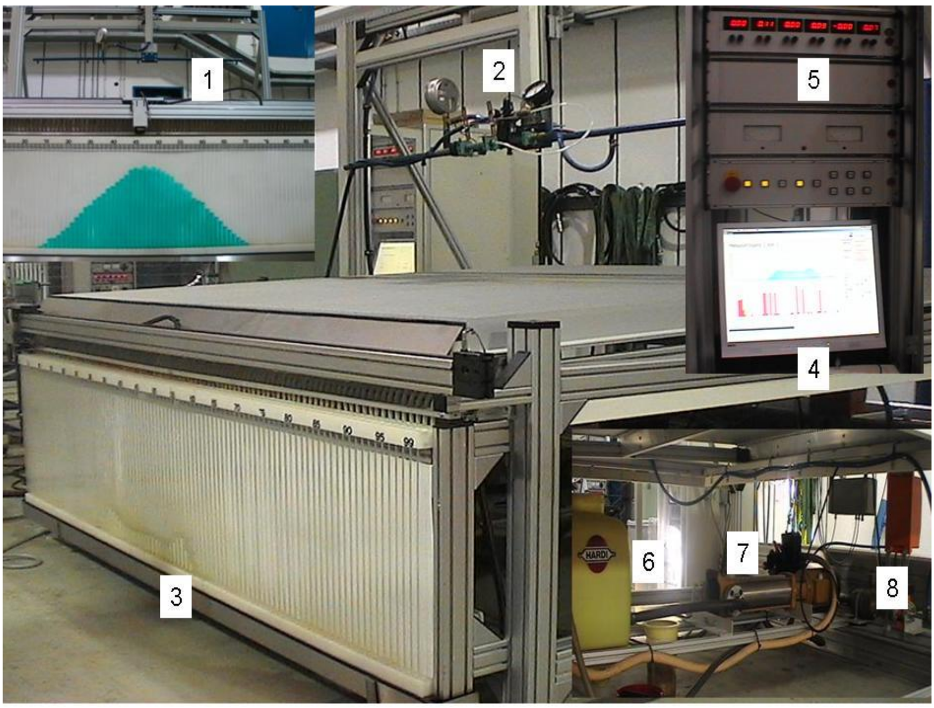


Fig. 1: The schismatic diagram of ultrasonic setup in full automatic Patternator in JKI laboratory.



1-Ultrasound sensor 2-Boom with pressure transeducar 3-Patternator 4-PC
5-Control unit 1 6-Spray tank 7-Pump 8-Control unit 2

Fig. 2: The full automatic Patternator for tests spray distribution of single nozzle in JKI laboratory.

The full automatic Patternator used in the Laboratory of JKI to test the new nozzles which produced in the marketing for agricultural field. The JKI make the recommendation and reported to evaluate the new nozzles for EU countries.

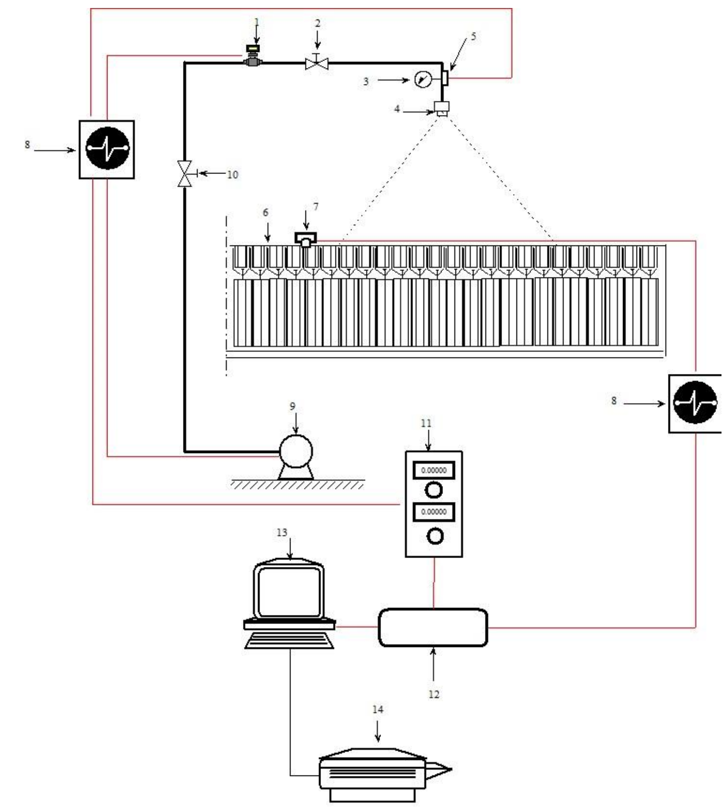
Table 1: The combinations of external mixing twin fluid (EMTF) nozzles

EMTF Nozzles	Nozzles	
	Air nozzles	Liquid nozzles
N 1	Lechler FT 5 - 608	Tee Jet TT110-3 POM
N 2	Lechler FT 5 - 608	Tee Jet TT110-5 POM
N 3	Lechler FT 5 - 608	Lechler LU120-15 POM
N 4	Lechler FT 5 - 608	Lechler LU120-04 POM
N 5	Lechler FT 5 - 608	Lechler LU90-04 POM
N 6	Lechler FT 5 - 608	Lechler AD120-04 POM
N 7	Lechler FT 5 - 608	Tee Jet XR8003 VS
N 8	Lechler FT 5 - 608	Tee Jet DG8004 VK

Procedures

The current research investigates the distribution for the developed low pressure external mixing twin fluid (EMTF) nozzle under laboratory conditions. The mean treatments for the current study are the type of nozzles in the EMTF combinations nozzles, nozzles height, co-angling (injection angle) and air pressure for EMTW nozzles that affecting on the spray uniformity distribution. The duration of spraying experiments are controlled by the AW system, each treatment operated for 240 second. Spray pressures of 150 kPa and 60 kPa are applied for reference nozzles and the EMTF nozzles respectively. The control valves in the full automatic Patternator were adjusted the pressure nozzles. The single nozzle in boom fixed at middle of the top on the patternator. The single nozzle was used to reduce the overlap that produced at using for several nozzles. To enable the height of nozzle of spray boom to be treated, the nozzle was mounted on the transporter.

The control unit for liquid pressure and flow-rate adjusted before the single EMTF nozzle used to obtain the operating pressure nozzles for every treatment. By operating of the sprayer and the compressor of air, the patterns for every nozzle were measured by the ultrasonic sensor as above mentioned and record to analyze the data.



1- Flow meter with transducer
2- Control valve
3- Manometer
4- Nozzles
5- Pressure transducer
6- Patternator
7- Ultrasound sensor
8- Control unit
9- Water pump
10- Control valve
11- Liquid flow rate and pressure control unit
12- Data acquisition system
13- PC
14- Printer

Fig. 3: The Schematic diagram of the Patternator system and their facilities to the spray distribution of single nozzle.

As well as, measurements were carried out through the long axis of the spray distribution at a constant scan speed. All measurements were made spraying water at a temperature of approximately 20° C. Environmental conditions were kept constant at a temperature of 20° C and a relative humidity between 70 and 80 %. Three replications are used for every treatment to obtain a high accuracy analysis of the results. The arrangement and statistical analysis of the experiments was according to randomized block design.

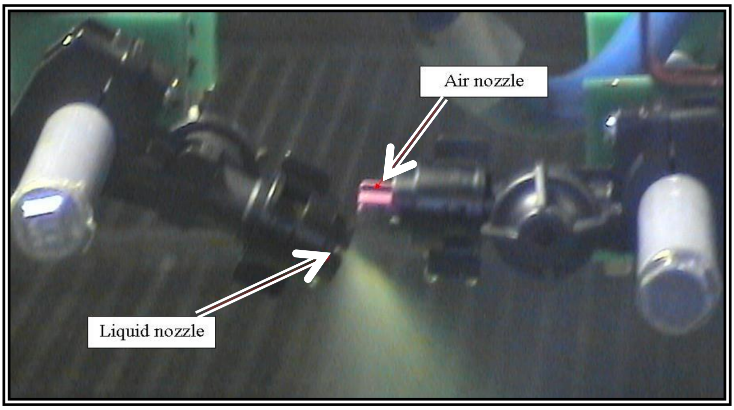


Fig. 4: The combination of a tongue nozzle (Lechler FT5.0- 608) for the air and a Tee Jet XR8004 VK for the liquid spray.

The hypotheses of the data analysis were to assume that the spray pattern distribution is affected by a number of factors and situations. The factors are the combination of EMTF nozzles, height of nozzle and injection angle. These include the pressure of air which used to atomize the liquid spray by Lechler FT 5 – 608 air nozzle. The conventional standard flat-fan Hardi ISO F 110-03 nozzles are used as the reference nozzles and compared its CV % result with the eight selected EMTF nozzles. The first and last tests of each of the measuring treatment were carried out using the Hardi ISO F 110-03 reference nozzle at 300 kPa to provide direct comparison with the spray distribution data at two different nozzle height 50 cm and 70 cm. The eight selected EMTF nozzles (Tee Jet TT110-3 POM, Tee Jet TT110-5 POM, Lechler LU120-15 POM, Lechler LU120-04 POM, Lechler LU90-04 POM, Lechler AD120-04 POM, Tee Jet XR8003 VS, and Tee Jet DG8004 VK) were operated at 60 kPa low liquid pressure. The two levels of air pressures in eight selected EMTF nozzles 150 (1.5 bar) and 200 kPa (2 bar) at liquid pressures 60 kPa (0.6 bar), two height of nozzle 50 cm and 70 cm, and two injection angles 60° and 45° were tried to study their effect on spray distribution, as well as to find the optimal nozzle configuration.

Coefficients of Variation (CV, %)

The AW system software program was used and with VB programming programmed the coefficient of variation. The coefficients of variation as the percentage of spray pattern for all nozzles treatment were programmed by using the standard equation and excluding the ends where there is no overlap. The coefficient of variation was programmed using the following formula (Herbst, A. and P. Wolf, 2001): Where C.V. is the coefficients of variation percentage, %, x_i is the height of liquid in the tube, cm and, n is the number of patternator columns.

In figure 5, indicates the test report for the EMTF nozzles which reported by the JKI in Braunschweig, Germany. This recommendation report is required to accept any new nozzles in EU countries. The data for every treatment were collected from the all reports for every treatment conditions. The spray volume in every tubes which measured by the Ultrasonic sensor were used to recalculated the CV % values. The CV % values were recalculated by using the functions 1, 2, and 3 as above mentioned to obtain a good accuracy for the CV % because the AW system programming sometimes give only an error values for CV %.

$$X' = \frac{\sum X_i}{n} \quad \text{.....................(1)}, \quad s = \sqrt{\frac{\sum (x_i - x')^2}{n-1}} \quad \text{.........(2) and} \quad CV = \frac{s}{x'} * 100 \quad \text{.................(3)}$$

RESULTS AND DISCUSSIONS

In the current investigation research, it will be investigate the spray distribution for different EMTF nozzles at different treatment tests conditions. The different combinations of EMTF nozzles, height of nozzle, air pressure, and co-angling are the main factor of treatment which affecting on the spray uniformity.

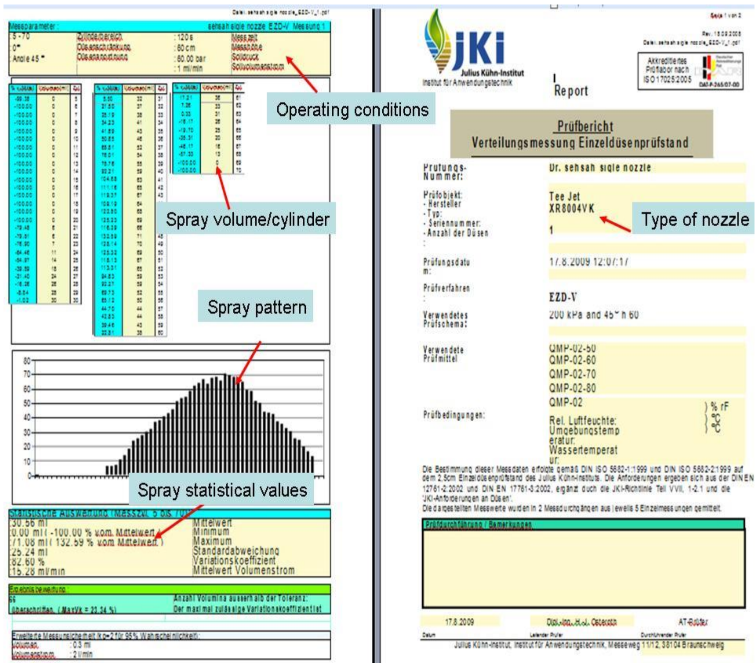


Fig. 5: The output results and the JKI recommendation reporter from AW system software program for the evaluation of the EMTF nozzles.

The uniformity distribution

The Coefficients of variation for all treatments are given in Tables 2, 3, 4 and 6 from the statistical analysis of these parameter data. It was shown that, the spray distribution is improved by good select of type of nozzles in the combination of EMTF nozzles, increasing of air pressure, reduces co-angling of nozzles and reduces the nozzle height. The type of nozzles is very important parameters which affect the distribution of pattern CV, % values as shown in Tables 2, 3, 4, and 6. The low value of coefficient (CV) of variation represents an indicator for good uniformity distribution. The combination of EMTF N3, N7 and N8 nozzles gave the better uniformity distribution compared to the N1, N2, N4, N5 and N6 EMTF nozzles. The N8 (Lechler FT 5–608 & DG800-04 VK) nozzle combination gave 11.0 % coefficient of variation percentage at 60 kPa liquid pressure and 50 cm nozzle height or boom height. On the other hand, the coefficient of variation percentage (CV, %) values for standard ISO nozzle at 300 kPa nozzle pressure were 10.2 % and 12.6 % at 50 cm and 70 cm nozzle height respectively. The selection of nozzles may be reduced the losses of spray dose and gives good distribution of pattern.

Effect of nozzle types and nozzle height on CV %

It is clearly that the types of nozzle in the external mixing twin fluid (EMTF) combined nozzles has an important influence on the reduction of the coefficient of variation percentage compared to the ISO 03 nozzle as shown in figure 6, 7 and 8. In table 2, the effect of the interaction of different EMTF nozzles type, nozzle height and co-angling were investigated to find their affecting on spray uniformity CV percentages. The interaction between nozzles type, nozzle height and co-angling was significant at 5 % level. The EMTF nozzle types N3, N7, and N8 produced the lowest CV % values compared to the N1, N2, N4, N5 and N6. On the other hand, the EMTF nozzle N8 (Lechler FT 5–608 & DG800-04 VK) produced the CV % nearly the standard ISO nozzle CV percentages values. Table 3 indicates the effect of the interaction of different EMTF nozzles type, height of nozzle and air pressure for EMTF nozzles were investigated to find their affecting on spray uniformity /CV percentages. The interaction between nozzles type, nozzle height and air pressure was non-significant at 5 % level. This result means that, it may able to use the low air pressure 150 kPa to operate the EMTF nozzles and reducing the energy and power requirement for EMTF nozzles. Table 4 illustrates the effect of the interaction of different EMTF nozzles type, co-angling and air pressure for EMTF nozzles were investigated to find their affecting on spray uniformity CV percentages. The interaction between nozzles type, co-angling 45° and air pressure was significant but the co-angling 60° was non-significant effect at 5 % level. Table 5 displays the interaction for all factors nozzles type, nozzle height, co-angling and air pressure for EMTF nozzles were investigated to find their affecting on spray uniformity CV percent. It noticed that, there are significant effects for nozzles type, nozzle height, co-angling and air pressure on spray uniformity CV percentages at 5 % level. The minimum CV % values for good spray distribution at 50 cm nozzle height, 45° co-angling and 200 kPa air pressure were 10.6 %, 12.9 % and 14.0 % for EMTF nozzle N8, N3 and N7, respectively.

The EMTF nozzle N8 produced the CV % nearly the standard ISO nozzle CV percentages values. In figures 6, indicate that there are non-significant different between the N8 (Lechler FT 5–608 & DG800-04 VK) EMTF nozzle and standard ISO nozzle at both nozzle height 50 cm and 70 cm. As well as the differences were statistically non-significant for the affecting of type of nozzles in EMTF nozzles combinations at two levels of co-angling on the spray distribution as shown in figure 7. It is clear that the external mixing twin fluid nozzles may be producing a good spray distribution at low liquid pressure. It is observed that the combinations of the external mixing twin fluid nozzles gave the highly effect on the CV % compared to the other factors, height nozzle, injection angle and air pressures. The external mixing twin fluid nozzle N1 (TT11003+ Lechler FT 5 - 608) produced the highest CV % compared to the N8 (Lechler FT 5–608 & DG800-04 VK) nozzles combinations at low liquid pressure 60 kPa (0.6 bar). It may therefore be concluded that the CV % values are more strongly dependant on the combinations of nozzles in the EMTF nozzles, which is highly significant in data.

In table 5, the effect of nozzles height was significant effect on CV % values of spray uniformity at both two levels of co-angles and air pressure. As well as, increasing of nozzle height tends to increase the CV percentages. The nozzle height 50 cm produced a good distribution compared to 70 cm height of nozzle as shown in table 5 and figure 6. AS well as, the combination of chosen testing height and co-angling therefore will affect CVs from each particular nozzle.

Effect of the co-angling on CV %

In table 2, the co-angling (injection angle) was significant effect on the CV % for all EMTF nozzles combinations N1, N3, N4, N5, N6, N7 and N8. On the other hand, the increase of injection angle tends to increase the CV % or losses of spray liquid. The injection angle 60° at 150 kPa (1.5 bar) air pressure gave the highest value of the CV % as shown in table 2 and figure 7. As well as, it was found that the 45° at 50 cm nozzle height gave a significant effect compared to the 60° injection angle at same condition. The 45° co-angling produced a good spray uniformity distribution compared to the 60° co-angling. A similar trend was found for the effect of the 45° at 200 kPa air pressures on the CV%. In figure 7 presented that the interaction of the effect of the type of nozzles and injection angle on the CV%. The optimum co-angling for EMTF nozzles was found at 45° that may be reduce the spray losses and produced a good uniformity spray distribution for all treatment conditions. The uniformity spray distribution CV percent values for N8 (Lechler FT 5–608 & DG800-04 VK) nozzle at the optimum co-angling 45°were 11.0 % and 12.1% at 50 cm and 70 cm nozzle height respectively. As well as the CV percent values for above nozzle at 60° co-angling were 13.2 % and 14.1 % at 50 cm and 70 cm nozzle height respectively. In addition to, the both 45° and 60° co-angling were non-significant effect on the CV percent values for interaction of the nozzles height, co-angle and air pressure. The CV percent values for 150 kPa air pressure were 17.7 % and 18.5 % at nozzle height 50 cm for 45° and 60° co-angling as shown in table 5, respectively. As well as, there are non effects of the interaction of co-angling with the all factors on the CV percentage as shown in table 6. The CV percent values for N8 (Lechler FT 5–608 & DG800-04 VK) nozzles combinations and 150 kPa air pressure were 13.2 % and 14.5 % at nozzle height 50 cm for 45° and 60° co-angling as shown in table 6 respectively. It may be able to use the 45° co-angling that will be easy to setting it by the operator.

Effect of air pressure on CV %

In tables 4, 5 and 6, the air pressure was non-significant effect on the CV % for all combined of EMTF nozzles N1, N2, N3, N4, N5, N6, N7 and N8. It is clearly that the air pressure is non importance factor affecting on the spray uniformity distribution pattern CV percentage. On the other hand, the statistical analysis indicated that, the interaction between the air pressures with injection angle was also non-significant effect on spray pattern distribution as shown in tables 5 and 6. A similar tendency was found in the effect of the interaction of air pressures with nozzle height on the CV percentage as shown in table 5. As well as, there are non effects of the interaction of air pressures with the all factors on the CV percentage as shown in table 6. The CV percent values for N8 (Lechler FT 5–608 & DG800-04 VK) nozzle and nozzle height 50 cm were 11.3 % and 10.6 % at air pressure 150 kPa and 200 kPa and co-angling 45° respectively. As well as, the CV percent values for N8 (Lechler FT 5–608 & DG800-04

VK) nozzle and nozzle height 50 cm were 11.8 % and 12.3 % at air pressure 150 kPa and 200 kPa and co-angling 60° respectively.

Table 2: The effect of combinations of the external mixing twin fluid (EMTF) nozzles, nozzles height and co-angle on CV % values of spray uniformity

EMTF nozzles	Spray uniformity , CV %			
	Nozzle height, 50 cm		Nozzle height, 70 cm	
	Co-angle, 45°	Co-angle, 60°	Co-angle, 45°	Co-angle, 60°
N1	22.3	26.8	24.5	28.7
N2	19.7	24.1	21.4	23.2
N3	**13.3**	**16.1**	**14.7**	**17.2**
N4	17.8	21.4	19.6	22.9
N5	18.7	22.5	20.5	24.1
N6	20.3	24.4	22.2	26.1
N7	**14.4**	**17.4**	**15.9**	**18.6**
N8	**11.0**	**13.2**	**12.1**	**14.1**

SE 0.37380 5%LSD 1.05598

Table 3: The effect of combinations of the external mixing twin fluid (EMTF) nozzles, nozzles height and air pressure on CV % values of spray uniformity

EMTF nozzles	Spray uniformity , CV %			
	Nozzle height, 50 cm		Nozzle height, 70 cm	
	150 kPa	200 kPa	150 kPa	200 kPa
N1	23.5	23.3	28.1	27.4
N2	20.8	20.3	23.6	23.8
N3	**14.1**	**13.9**	**16.8**	**16.4**
N4	18.8	18.6	22.4	21.9
N5	19.7	19.5	23.6	23.0
N6	21.3	21.2	25.5	24.9
N7	**15.2**	**15.1**	**18.2**	**17.8**
N8	**11.6**	**11.5**	**13.8**	**13.5**

SE 0.373801 5%LSD 1.05598

Table 4: The effect of combinations of the external mixing twin fluid (EMTF) nozzles, co-angle and air pressure on CV % values of spray uniformity

EMTF nozzles	Spray uniformity , CV %			
	45° Co-angle		60° Co-angle	
	150 kPa	200 kPa	150 kPa	200 kPa
N1	24.9	24.2	26.6	26.5
N2	22.1	21.8	22.3	22.4
N3	**14.9**	**14.5**	**16.0**	**15.9**
N4	19.9	19.3	21.3	21.2
N5	20.9	20.3	22.4	22.2
N6	22.6	22.0	24.2	24.1
N7	**16.2**	**15.7**	**17.3**	**17.2**
N8	**12.3**	**11.9**	**13.1**	**13.1**

SE 0.37380 5%LSD 1.05598

Table 5: The effect of nozzles height, co-angle and air pressure effect on CV % values of spray uniformity

EMTF nozzles height, cm	Spray uniformity , CV %			
	Co-angle 45°		Co-angle 60°	
	150 kPa	200 kPa	150 kPa	200 kPa
50	17.7	16.6	18.5	19.2
70	20.7	20.8	22.3	21.4

SE 0.186901 5%LSD 0.527988

It was no different between the CV percent values for same EMTF nozzle N8 (Lechler FT 5–608 & DG800-04 VK) at nozzle height 70 cm and co-angling 45° for both air pressure 150 kPa and 200 kPa. The air pressure 150 kPa produced the nearly CV % values compared to 200 kPa air pressure for all EMTF nozzles. In figure 8 illustrate no different CV % values between the two air pressure 150 kPa and 200 kPa. It may be able to use the low air pressure to reduce the power requirements in the operation of EMTF nozzles.

Table 6: The effect of combinations of the external mixing twin fluid (EMTF) nozzles, nozzles height, co-angle and air pressure on CV % values of spray uniformity

EMTF nozzles	Height, cm	Spray uniformity , CV %			
		Co-angle 45°		Co-angle 60°	
		150 kPa	200 kPa	150 kPa	200 kPa
N1	50	23.1	21.5	23.9	25.0
N1	70	26.8	26.9	29.4	28.0
N2	50	20.1	19.3	21.5	21.3
N2	70	24.1	24.2	23.1	23.4
N3	50	**13.8**	**12.9**	**14.3**	**15.0**
N3	70	**16.1**	**16.1**	**17.6**	**16.8**
N4	50	18.4	17.2	19.1	20.0
N4	70	21.4	21.5	23.5	22.4
N5	50	19.3	18.1	20.1	21.0
N5	70	22.5	22.5	24.6	23.5
N6	50	20.9	19.6	21.7	22.7
N6	70	24.3	24.4	26.7	25.4
N7	50	**14.9**	**14.0**	**15.5**	**16.2**
N7	70	**17.4**	**17.4**	**19.1**	**18.2**
N8	50	**11.3**	**10.6**	**11.8**	**12.3**
N8	70	**13.2**	**13.2**	**14.5**	**13.8**

SE 0.528635 5%LSD 1.49338

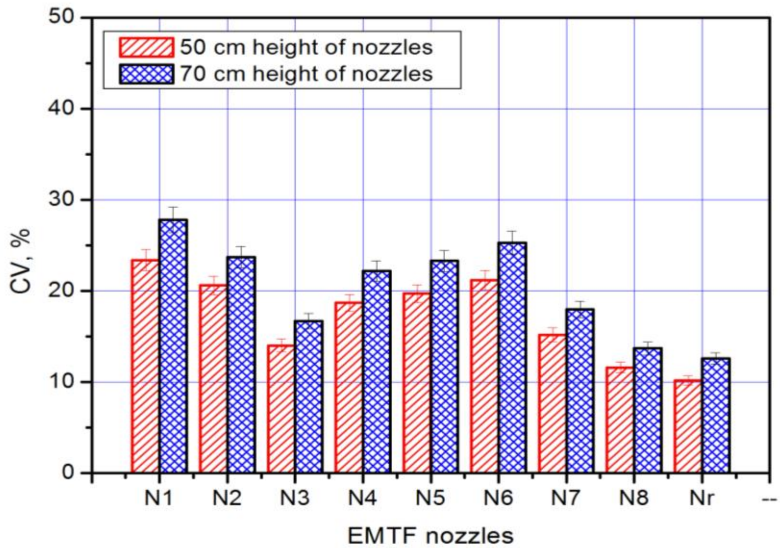


Fig. 6: The effect of type of EMTF nozzles, nozzles height on the spray distribution, CV%.

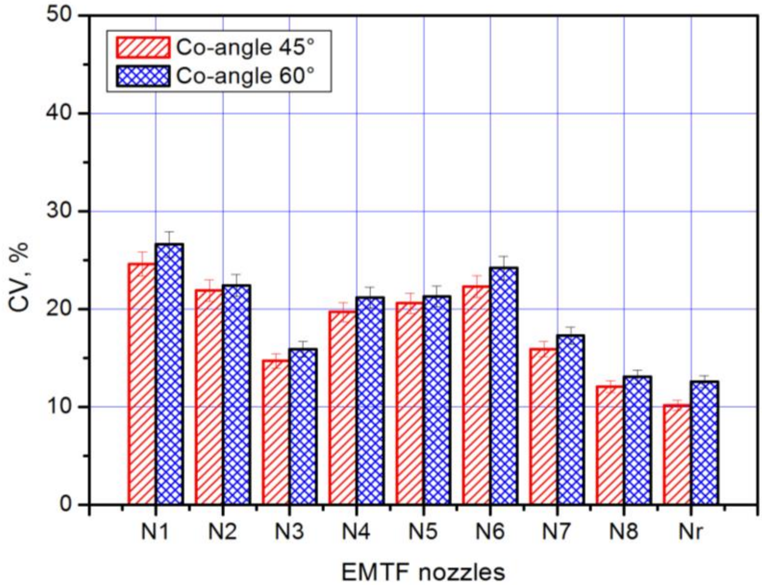


Fig. 7: The effect of type of EMTF nozzles and co-angling of EMTF nozzles on the spray distribution, CV%.

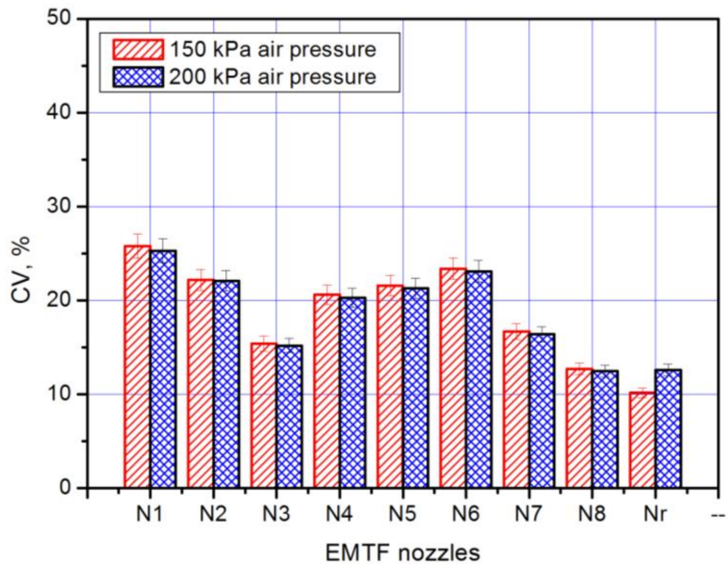


Fig. 8: The effect of type of EMTF nozzles and air pressure of EMTF nozzles on the spray distribution, CV%.

CONCLUSIONS

From the above two research parts that focused on the investigations and evaluation of new EMTF nozzles. The EMTF nozzles may able to produce the spray spectra from fine to very fine droplets with low power requirement. In addition, the EMTF nozzles may be able to reduce the drift, soil sedimentation and good deposition values. The results indicated that the nozzle types and nozzles height affect the spray uniformity distribution. The decreasing of nozzle height tends to increase the uniformity of spray and the coverage of spray dose. As well as, there is non-significant effect of air pressure under laboratory condition on uniformity of dose. For the different EMTF nozzle combinations, CV % values of the N8 nozzle which combined from Lechler FT 5-608 with Tee Jet DG8004 VK nozzle was always nearly than the CV % values compared to the standard ISO nozzle at liquid pressure 60 kPa(1 bar) and 50 cm nozzle height. The optimum co-angling for EMTF nozzles was found at 45° that may be reduce the spray losses and produced a good uniformity spray distribution As well as, it may able to use the low air pressure 150 kPa to operate the EMTF nozzles and reducing the energy and power requirements.

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الملخص العربى

تقييم كفاءة انتظامية توزيع سائل الرش للفوانى ذات الضغط المنخفض والخلط الخارجى لمائعين

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أجريت هذه الدراسة بمركزالبحوث الفيدرالى للعلوم الزراعية و الغابات معهد **JKI** **(Application Techniques Division)** بمدينة برونشفيج بألمانيا. حيث تهدف هذه الدراسة فى الجزء الثالث منها الى دراسة تقييم كفاءة أنتظامية توزيع سائل الرش للفوانى ذات الخلط الخارجى لمائعين (الهواء+السائل) وذلك بأختبارهم معمليا بواسطة وحدة قياس توزيع سائل الرش الأوتوماتيكية **full automatic Patternometer** ، حيث أن الفوانى ذات الخلط الخارجى تعتبرمناسبة لتطبيقات المكافحة الحيوية وهى أيضا تقلل من حجم المياه المستعملة فى الرش نظرا لقلة معامل تصرفها و كذلك الطاقة و التكاليف اللازمة لعمليات المكافحة و بالتالى صيانتها.

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و لأجراء ما سبق تم أستعمال الفواتى **Lechler FT5.0 608** كمصدر للهواء و الذى سبق أستعماله فى الجزء الأول و الثاتى من هذه الدراسة مع ثمانية أنواع من الفوانى لسائل الرش بغرض الحصول على التركيبات التالية **N1, N2, N3, N4, N5, N6, N7, N8** من الفوانى **EMTF** ذات الخلط الخارجى لمائعين(الهواء + السائل). كما أجريت الأختبارات لدراسة أربعة عوامل رئيسية هى نوع الفوانى فى تركيبة الفوانى **EMTF** ، أرتفاع الفوانى ، زاوية حقن سائل الرش، ضغط الهواء المستعمل قى ترذيذ سائل الرش على أنتظامية سائل الرش. و فى دراسة تأثير نوع الفوانى على أنتظامية سائل الرش أستعملت التركيبات الثمانية من الفوانى **EMTF** و ذلك عند أرتفاعين للفوانى هما ٥٠ سم و ٧٠ سم و زاويتن لحقن سائل الرش هما ٤٥° و ٦٠° و ضغطين لفوانى الهواء هما ١٥٠ ك.بسكال و ٢٠٠ ك.بسكال. ولقد تم دراسة تأثير تفاعل العوامل السابقة وتأثير التداخل فيما بينها على أنتظامية سائل الرش. كما تم أخذ و تسجيل البيانات بواسطة برنامج الحاسوب **AW system** المستعمل فى تسجيل القراءات المقاسة بواسطة **Ultrasonic sensor** لتقدير و حساب معامل الأختلاف الذى هو دالةعلى أنتظامية سائل الرش. كما أستعملت الفوانى **standard flat-fan Hardi ISO F 110-03** كمرجع قياسى و التى تم قياس معامل الأختلاف لها عند الضفط القياسى لها ٣٠٠ ك. بسكال لمقارنة نتائج أنتظامية توزيع سائل الرش الناتج منها بنتائج أنتظامية توزيع السائل للفوانى **EMTF** عند كلا الارتفاعين للفوانى ٥٠ سم و ٧٠ سم.

<u>أهم النتائج المتحصل عليها</u>

وجد من النتائج المتحصل عليها أن أستخدام الفوانى ذات الخلط الخارجى لمائعين(الهواء + السائل) **N8** ذات التركيبة **(Lechler FT 5 – 608&Tee Jet DG80-04 VK)** والفوانى **N7** **(Lechler FT 5 – 608&Tee Jet XR8003)** وكذلك الفوانى **N3** (**Lechler FT 5 – 608&Lechler LU120-15 POM**) أعطت أقل قيم لمعامل الأختلاف مقارنة بباقى تركيبات الفوانى **N1, N2, , N4, N5, N6** كما أن الفوانى **N8** **(Lechler FT 5 – 608&Tee Jet DG80-04 VK)** أعطت أنتظامية لسائل الرش عتد ضعظ منخفض لسائل الرش ٦٠ ك. بسكال مماثل للفوانى القياسية **standard flat-fan Hardi ISO F 110-03**. و فى دراسة تأثير أرتفاع الفوانى وجد أنه بزيادة الأرتفاع يؤدى الى زيادة معامل الأختلاف أى أنخفاض أنتظامية السائل. كما أن زاوية حقن سائل الرش كان لها تأثير معنوى فقط على أنتطامية التوزيع حيث أعطت الزاوية ٤٥ أفضل قيم لمعامل الأختلاف و ذلك عند دراسة تأثير التداخل مع أرتفاع سائل الرش و نوع الفوانى ، بينما لم يكن لها تأثير مع باقى العوامل على أنتظامية سائل الرش أو معامل الأختلاف وبناء على ذلك فأنه يوصى بأستعمال الزاوية ٤٥ لسهولة ضبطها لدى المشغل. و فى دراسة تأثير ضغطى الهواء لفوانى الهواء **Lechler FT 5 – 608** وجد أنها ليس لها أى تأثير معنوى على معامل الأختلاف و بالتالى الأنتظامية كما أنه يفضل أستعمال الضغط المنخفض لها و هو ١٥٠ ك.بسكال (**bar** ١,٥) و بالتالى خفض القدرة الازمة للتشغيل والتكاليف.