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EFFECT OF LOW PRESSURE LIQUID ATOMIZERS USAGE IN BIOLOGICAL PEST CONTROL

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ABSTRACT

There is a growing concern about the known and unknown consequences of pesticides on environment and human health and in some countries there is already a strong public pressure to reduce their use. For these reasons, alternative approaches to pest control are used more and more and the concept of integrated pest management where synthetic pesticides are only applied as a last resort is now considered as a common practice in professional agriculture. The non-chemical alternatives include cultural practices, choice of resistant varieties, creation of a favorable environment for natural enemies of pests and the use of biological products and agents, including beneficial insects. Field application of living organisms with flat-fan nozzles and a liquid pressure up to 100 kPa is considered to be resolved.

The present study was carried out to investigate the effect of three different types of low pressure liquid atomizers (Rotary atomizer, external mixing twin-fluid nozzles and flat-fan nozzle) on the survival rate of living organisms. It was conducted at the University of Hohenheim, Institute of Agriculture Engineering. The effect of nozzle size, liquid pressure (50 and 88 kPa) and rotational speed of the rotary cage atomizer on viability reduction of Trichogramma Brassica and Encarsia Formosa were investigated under laboratory conditions in a randomized design with three replications. The organisms were suspended in water by a mechanical agitator with 200 rpm in a small air-pressured tank. The control sample was collected from the end of the liquid line without atomizer. The organisms were filtered out of the spray fluid, dried, stored under ambient temperature and counted for living individuals after 14 days.

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With the flat-fan nozzle (XR8003) at 100 kPa liquid pressure, according to the field application technique, the mean value of viability reduction was 11.9 % for T.Brassica and was 13.3 % for E. Formosa.by increasing rotational speed of the rotary atomizer, the centrifugal force increased and correspondingly the shear stress on the fluidized eggs of T.Brassica and E.Formosa. The highest mean value of viability reduction was 20.8 % for T. Brassica and was 34.7 % for E. Formosa at(5500 rpm) and 50 kPa liquid pressure. With 2000 rpm the viability reduction values were 9.9 % and 15.3 % respectively. With a comparable VMD of around 120 μm the external mixing twin-fluid nozzles (88 kPa for liquid) produced a viability reduction of 10.5 and 11.5 % for T. Brassica and E. Formosa, respectively.

In this laboratory experiment, it could be shown that a low pressure atomization (<100 kPa) of living organisms in watery suspension is possible. Particularly the results of the external mixing twin-fluid nozzles are very promising. The viability reduction rates which are already below the standard field application can even be improved at the expense of increasing droplet sizes.
Key words: low pressure, atomizers and biological control.

INTRODUCTION

Beneficial organisms, such as predators and parasites, are increasingly used as an alternative to pesticides for agricultural pest control,(Matthews, 1992). The living organisms can be easily damaged during handling and distribution and are often applied by hand labor. The high labor cost impedes conversion from pesticide use to use of bio-control releases. The effects of environmental conditions and mechanical treatment on the viability of such organisms are being studied. Fife et al. (2003) cited that, few bio-pesticides are currently being used commercially as alternatives to chemical pesticides (Gan-Mor and Matthews, 2003), representing little more than 1% of total world pesticide market (Menn and Hall, 1999). Bio-pesticides are mainly being used in niche markets where no effective chemical pesticides are available, organic farms, and where high-value crops are being grown under

controlled conditions (Jacobsen and Backman, 1993). Mills (1996) developed a ground delivery system to broadcast an even dispersion of Trichogramma platneri through the canopy of a commercial walnut orchard. He demonstrated that the extent of damage to walnuts by codling moth can be reduced by as much as 70% by releasing Trichogramma platneri on four occasions through the egg-laying period of each of the three successive generations of the codling moth through the season. The objectives of current study aremay be conculded as follows:
To determine the extent of damage to a biological pest control agent (Bio-pesticides), due to the effects of three different type techniques of hydraulic liquid atomizer under low operating pressure. The yield of living organisms and biological-dynamic preparations must take place on the one hand during as low operating pressure and a shear stress as possible, on the other hand, one an even distribution and good quality are demanded. In addition to, the adaptation and examination of sprayer under low operating pressure (< 1 bar) of living organisms (T.Brassica and E.Formosa).

MATERIAL AND METHODS

Instruments:

A Proptec rotary drum atomizer unit was used, it is consisting of an open-ended, thick walled, rotating plastic cylinder with a series of longitudinal slots. The liquid distribution system consisted of a metal liquid feed channel with holes leading to a series of grooves on the insides of the vanes between the slots. The open ended design allowed the drum to act as a small centrifugal fan. The rotary atomizer unit was used at different rotational speed (1000, 2000, 3000, 4000, and 5500 rpm) and operating pressure of 50 kPa. Flat-fan Lechler nozzles (XR8003, XR8004 and XR8005) were used as standard nozzles with two living organisms and at low operation pressure 100 kPa and 200 kPa. Also, the external mixing twin-fluid nozzles consisting of a Lechler air nozzles FT 5.0-608 and liquid nozzles Tee jet (TT11003VP, TT11004VP and TT11005VP). It has constructed to study the effect of low operating pressure and air assisted atomizer on reduction percent of living organisms (T. Brassica and E. Formosa) emergence. The co-angling between the air nozzles and liquid nozzles was 40^{o}. Also, two different operating pressure 50 and 88 kPa were used with air assisted atomizer and without air assisted atomizer. The tachometer of C118 was used to measure the rotational speed for rotary atomizer. The Testo instrument mode 445 was used to measure the wind speed (m/s), air temperature (^{o}k) and relative humidity (%). A steel tank with 10 liters capacity was used to establish and maintain the watery suspension of the living organisms (T.Brassica and E.Formosa) in the water. The mechanical agitator with three blades rotated at 200 rpm driven by an electric motor (500 W). The tank included a safety valve working at 400 kPa maximum operating pressure. The air inlet was at top of the tank and controlled with the regulator to obtain the liquid pressure requirement **Fig. 1**.

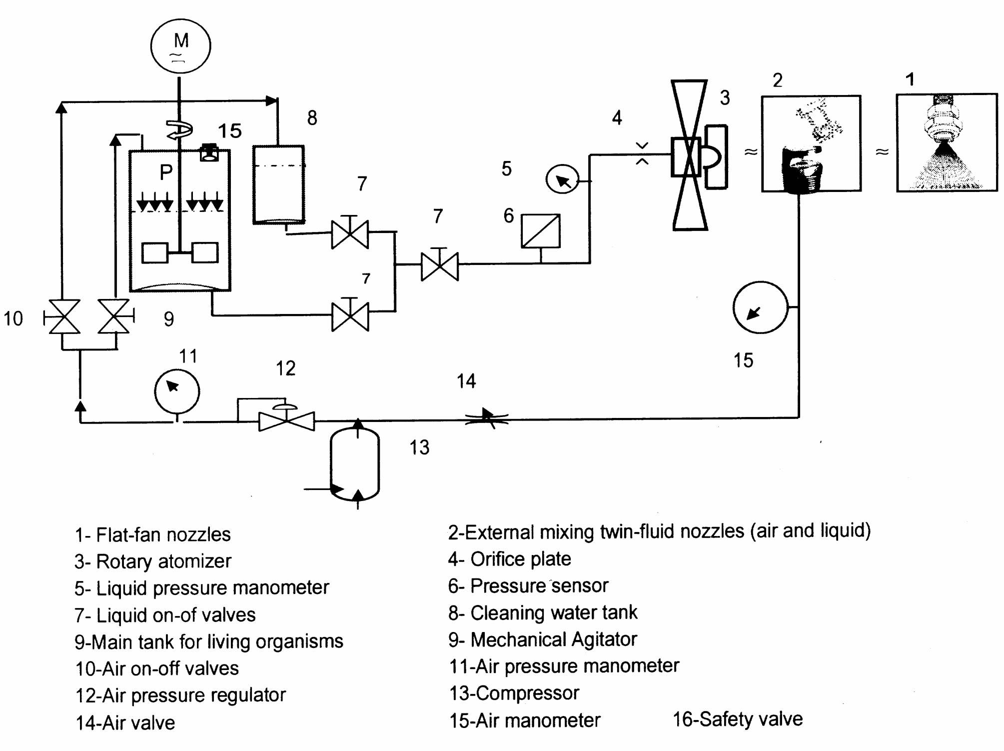

Fig. 1: Diagram for laboratory test of different techniques low pressure liquid atomizers

Sample Collection and preparation:

Two different types of living organisms (Bio-pesticide), T.Brassica and E.Formosa were used in the three different techniques for liquid atomizer and laboratory tests conditions. The row material of T.Brassica was used from AMW Nützlinge Gmbh Company (Ausserhalb54, 64319pfungstadt– Germany) under their recommendation. The Loose eggs E.Formosa was from Sautter and Stepper Gmbh Company (Rosenstr.19, D-72119 Ammerbuch, Germany). The concentration for T.Brassica and E.Formosa was 500 loose eggs per liter and for Encarsia Formosa was 50 loose eggs per liter.By rotating the mechanical agitator and pressurized the liquid in the main tank to the different atomizers, the parasitized host eggs was transferred into the different techniques through the orifice plate. To collect the sample from the rotary atomizer, a plastic container with a diameter of 750 mm was used. The control sample was collected from the end of the liquid line without working the rotary atomizer and other atomizers. The samples were transferred to a measuring cylinder and poured through a filter bag to collect the living organisms. The filter papers were collected and dried for 3 hours at the host eggs and were transferred to the emergence container. The living organism's loose eggs stayed in the emergence container until for two weeks. The samples from the external mixing twin-fluid nozzles and standard nozzles were collected by using the same way as from rotary atomizer. After every treatment, the collecting sample container was washed to remove the residuals living organisms by using the cleaning tank and stop valves.

Viability reduction:

The viability reduction percent for T.Brassica and E. Formosa (REP) was calculated by using the following equation :

$$VRP = [1 - \frac{ERT}{ERN}] \, 100$$

Whereas:

VRP = Viability reduction, %;

ERT =Emergence rate of the treatment organisms, decimal and

ERN =Emergence rate of the non-treatment organisms , decimal.

The emergence rate of the treated organisms was estimated by counting the blackened pupae host eggs without hole After 10 days the pupae emerges with hole was counted. The rate was calculated by the number of pupae emerges divided to total host eggs without hole for each treatment and non-treated T.Brassica and E.Formosa.

RESULTS AND DISCUSSION

The experimental randomization completely design was designed with three replication to investigate the effect of different techniques liquid atomizer and their conditions on viability reduction of T.Brassica and E.Formosa under laboratory conditions.

Effect of rotary atomizer on viability reduction :

Fig. 2 indicates the effect of rotating speeds of rotary atomizer on the viability reduction of living organisms for T.Brassica and E.Formosa. The high values of rotational speed of rotary atomizer gave high values of viability reduction of living organisms. It is clear that, the viability reduction for each living organisms T.Brassica and E.Formosa tend to increase by increasing the rotating speed because the rotating drum of rotary atomizer at high speed shearing or affected on the loose eggs for T.Brassica and E.Formosa. The mean values of viability reduction of T.Brassica were 6.5 , 9.9 , 11.6, 12.1 and 20.8 % at revolution speed values of (1000, 2000, 3000, 4000, 5500 rpm) of rotary atomizer. Further more, the values of E.Formosa at the same rotating speeds were10.6 , 15.3, 23.1, 29.3 and 34.6 %. Analysis of variance showed thatthe rotary atomizer speed had a highly significant effect on the viability reduction for T.Brassica and E.Formosa.

Effect of Flat fan nozzles on viability reduction

It is clear that, increasing the operating pressure tends to increase the reduction percent for both T.Brassica and E. Formosa. In addition to, the gross orifice nozzles gave the low viability reduction for both T.Brassica and E.Formosa. Also, **Fig. 3** illustrates the effect of flat-fan nozzles XR8003, XR8004 and XR8005 at 100 and 200 kPa on viability reduction for T.Brassica and E.Formosa. The mean values of viability reduction for T.Brassica at 100 kPa were 11.9, 10.6 and 5.1% for nozzles of XR8003, XR8004 and XR8005 ,respectively. Also, the viability reductions for T.Brassica at 200

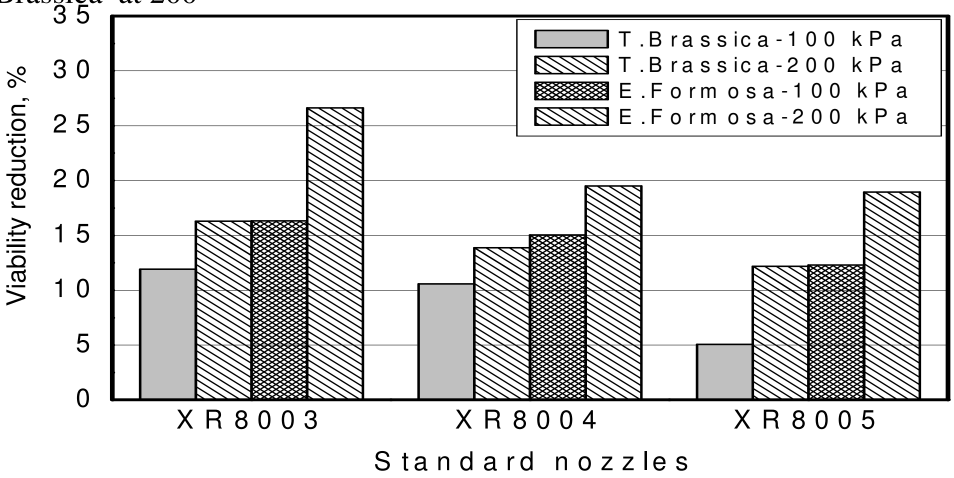

Fig. 2: Effect of rotational speed of rotary atomizer on viability reduction of living organisms.

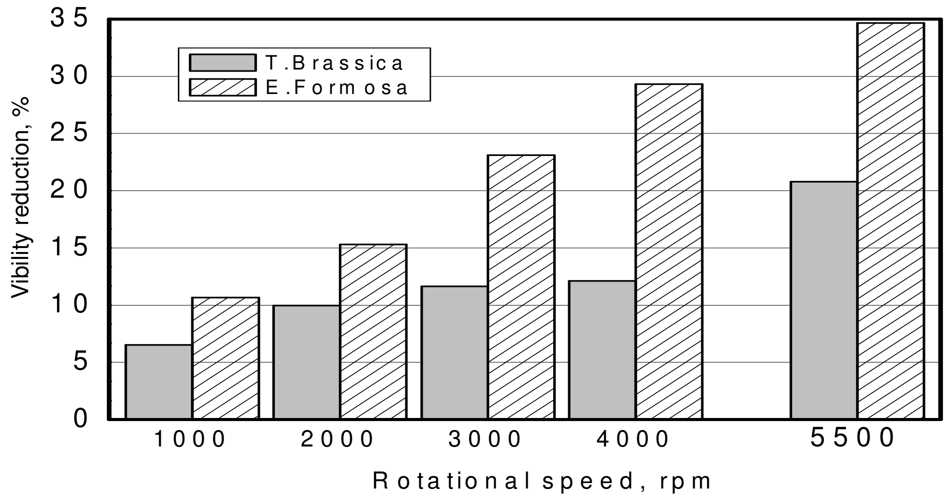

Fig. 3: Effect of standard nozzles size and low pressure on the viability reduction of living organisms.

kPa and three standard nozzles were 16.3, 13.88 and 12.2 % respectively. Similarly, the reduction percent ages of E.Formosa at the same conditions of100 kPa and three standard nozzles was 13.3 , 15.0 and 12.2 %. The viability reduction for E.Formosa at 200 kPa and three standard nozzles were 26.6, 19.5, and 18.8 %. It is clear that, the small orifice and high operating pressure increased the damage of T.Brassica and E.Formosa comparing with the large orifice and low pressure for flat-fan nozzles.

Effect of external mixing twin-fluid nozzles on viability reduction

The suitable co-angling (injection angle) between the air nozzle and liquid nozzles was found at 40^o. Also, two different operating pressures of 50 and 88 kPa were used with assisted air atomizer and without assisted air atomizer under 150 kPa for air nozzle. **Fig. 4** indicates the effect of external mixing twin-fluid nozzles on viability reduction for T.Brassica and E.Formosa. It is clear that; the increasing of operating pressure tends to increase the damage of T.Brassica and E.Formosa by increase the viability reduction for both T.Brassica and E.Formosa. Also, the large office gave the low values of viability reduction for T.Brassica and E.Formosa comparing with the small orifice of wide range nozzles. The mean values of viability reduction of T.Brassica were 10.4, 8.9 and 5.6% at 50 kPa for three nozzles of TT11003 PV, TT11004 PV and TT11005 PV, respectively.

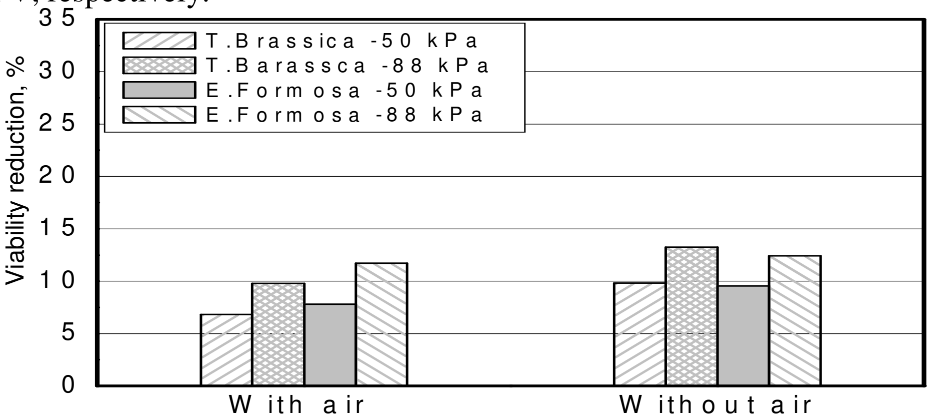

Fig. 4: Effect of air stream of external mixing nozzles, nozzle size and low pressure on the viability reduction of living organisms

As well as the emergence percent ages at 88 kPa for T.Brassica and the three nozzles were 13.1, 12.2 and 9.29% respectively. Similarly, the viability reductions for E.Formosa at 50 kPa was 11.5%, 8.6% and 5.8% for three nozzles of TT11003 PV, TT11004 PV and TT11005 PV respectively. Also, the viability reduction of E.Formosa at 88 kPa and for the same nozzles were 14.9, 12.4, and 8.8 %. The assisted air of external mixing twin-fluid nozzles, types of nozzles and low operating liquid pressure were investigated and their effected on the viability reduction of T.Brassica and E.Formosa. The assisted air atomizer tends to increase the viability reduction for T.Brassica and E.Formosa comparing to the without assisted air. Also, the interaction between the assisted air and pressure was non significant; and the interaction between assisted air and types of nozzles was non significant this result is according with the results of Sehsah,.2005.

Compression between the three techniques low pressure liquid atomizers

The obtained data presented in Table 1 indicate the effect of different types of liquid atomizers conditions on viability reduction values of living organisms (T.Brassica and E.Formosa). The rotary atomizer gave the high values of viability reduction for T.Brassica and E.Formosa comparing with the two alternative hydraulic liquid atomizer external mixing liquid and standard nozzles at the low operating pressure of 50 kPa (for both rotary atomizer and external mixing liquid) and 100 kPa for standard nozzles. Also, the standard nozzles gave the high values of viability reduction for T.Brassica and E.Formosa comparing with the external mixing liquid, because the operating pressure for the external mixing nozzles was less than the operating pressure for standard nozzles (Lechler, XR8003, XR8004 and XR8005). In summarized, the large orifice and the low revolution speed of rotary atomizer gave the best values of viability reduction for both living organism.(%)

With the flat-fan nozzle of XR8003 at 100 kPa liquid pressure for comparison to field application technique the mean value of viability reduction for T.Brassica was 11.9% and for E.Formosa was 13.3 %. With increasing rotational speed of rotary atomizer the centrifugal force increased corresponding the shear stress on the fluidized eggs of T.Brassica and E.Formosa. The highest mean values of viability reduction for T.Brassica and E.Formosa were 20.8 and 34.7 % at (5500 rpm) and 50 kPa respectively. The viability reduction values for both living organisms at (2000 and 3000 rpm) were 9.9, 15.3; 11.6 and 23.1%, respectively. The droplet size VMD for rotary atomizer at (2000, 3000 rpm) and 50 kPa were 121 µm and 93 µm. Also, the droplet sizes VMD for external mixing liquid atomizer at 50 kPa and 88 kPa were 145 µm and 120 µm ,respectively. With a comparable VMD of around 120 µm the external mixing twin-fluid nozzles at 88 kPa liquid pressure and TT11005 PV liquid nozzle produced a viability reduction of 13.1% with T.Brassica and 14.9% with E.Formosa.

CONCLUSION

In this laboratory experiment it could be shown that a low pressure atomization (<100 kPa) of living organisms suspended in water is possible. Particularly the results of the external mixing twin-fluid nozzle are very promising. The viability reduction rates which are already below the standard field application can even be improved at the expense of increased droplet sizes. With reference to a comparable volume rate and VMD the rotary cage atomizer gave reasonable values of viability reduction compared with the flat fan nozzle (XR8003) at 100 kPa and the external mixing twin fluid nozzles at 50 kPa only at m/s speed (1000 rpm rotational speed). But, a sufficient air stream from the connected axial fan can not be expected with this rotational speed. With a sufficient airstream at (2000 to 2500 rpm). the viability reduction for both living organisms is still in the range of the flat fan nozzle (XR8004, 100 kPa). The round orifice of the TT100X nozzle seems to be easy to the large pupa of E. Formosa. With the hydraulic atomizers of course there is a possibility to further improvement by increasing nozzles size and correspondingly increasing water volume rate. The large orifice of flat-fan nozzles had a less effect on damage of *T.Brassica* and *E.Formosa* compared to the small orifice flat-fan nozzles. The rotational speed of rotary atomizer was highly significant effect on the damage of *T.Brassica* and *E.Formosa*

Table 1: The viability reduction of living organisms for different hydraulic liquid atomizers

Liquid atomizer	Conditions		VMD, µm	Volume rate, l/ha	Flow rate, l/min	Viability reduction, %	
	Speedm/s (rpm) And type	Pressure, kPa				T. Brassica host eggs	E. Formosa loose pupa
Rotary atomizer	-(1000)	50	180	200	1.30	6.5	10.9
	-(2000)		123			10.0	15.3
	-(3000)		92			11.6	23.1
External mixing twin-fluid nozzle	TT 11003	50	102	149	0.56	10.4	11.5
	TT 11004		144	197	0.74	8.9	8.7
	TT 11005		163	267	1.00	5.6	5.8
Flat fan nozzle	XR 8003	100	219	232	0.87	11.9	13.3
	XR 8004		251	283	1.06	10.9	15.0
	XR 8005		288	339	1.27	5.1	12.3

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الملخص العربى

تأثير استخدام مرززات الضغط المنخفض فى المكافحة الحيوية للآفات

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يتزايد القلق من استخدام المبيدات الكيميائية بشأن النتائج المجهولة و المعروفة منها فى تأثيرها على كل من الإنسان و البيئة ، إلا أن هناك بعضا من الدول التى قد أخذت بالفعل فى تقليل المبيدات والحد من استعمالها. لهذا السبب فان الوسائل البديلة فى المكافحة بدأت فى التزايد والاستخدام ، وبخاصة فى برامج المكافحة المتكاملة. و من البدائل التى تستعمل فى المكافحة، استخدام بعض التطبيقات الزراعية والمكافحة البيولوجية و الحيوية. و استعمال الفيروسات و البكتريا و المتطفلات

وتهدف هذه الدراسة التى تم أجرائها بمعهد الهندسة الزراعية بجامعة هوهنهايم بألمانيا إلى البحث فى تأثير ثلاثة أنواع مختلفة من المرززات على إمكانية استخدام النظم التكنولوجية المختلفة فى ترزيز السائل فى رش المواد الحية المستخدمة فى المكافحة الحيوية للآفات. و المرززات الثلاثة ، أحدها تم تطويره ليعمل تحت ضغط سائل منخفض وصلت قيمته إلى اقل من الضغط الجوى و يتكون من نوعين مختلفين من الفوانى احدها للسائل وهى: Teejet TT11003,TT11004 and TT11005 والأخر للهواء Lechler Nozzle FT 5.0-608. كما استعمل المرزز الدورانى Proptec Rotary Atomizer و كذلك الفوانى القياسية Standard Nozzles XR8003, XR8004 and XR8005 فى التجربة التى تم تصميمها إحصائيا على إن تكون فى التصميم الكامل العشوائية كما استعمل أيضا نوعين مختلفين

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من بويضات المتطفلات الحية التى تستعمل فى المكافحة الحيوية وهى التريكوجراما و الانكارزيا فورموزا. و لقد بينت النتائج ما يلى:

أن هناك إمكانية لرش المواد المستخدمه فى المكافحة البيولوجية (المتطفلات) عند ضغوط منخفضة لسائل الرش حيث وجد أن المرزز الدورانى قد أعطى أعلى قيم لنسب الفواقد فى حيوية المتطفلات للفقس مقارنة بباقى المرززات عند السرعات الدورانية العالية. حيث بلغت نسبة الانخفاض فى حيوية المتطفلات والتى تعبر أيضا عن نسبة الفاقد من المواد البيولوجية الحية إلى ٢٣,١ % للانكارزيا فورموزا و ١١,٦ % للتريكوجراما عند سرعة دورانية٣٠٠٠ ك/و(-م/ث) للمرزز Proptec rotary atomizer. كما بلغت قيم نسب الفواقد فى كل من الانكارزيا فورموزا و التريكوجراما عند استعمال الفوانى Standard nozzles XR8003 هى ١٣,٣% و ١١,٩% على الترتيب. حيث كان من الواضح تأثير قطر المرززات على المواد البيولوجية إذ انه بزيادة قطر الفوانى يقل نسب الفاقد من المواد البيو لوجية و هذا أيضا ما قد لوحظ عند استعمال الفوانىExternal mixing twin fluid nozzles المطورة بمعهد الهندسة الزراعية بجامعة هوهنهايم بألمانيا. حيث وجد اقل نسب للفواقد عند الأقطار الكبيرة ل TT11005 nozzles و ٥,٨ % و٥,٦% لكل من الانكارزيا فورموزا و التريكوجراما .

و بمقارنة النتائج المتحصل عليها من النظم الهيدروليكية الثلاثة لرش المواد البيولوجية يتضح أن هناك حدود للسرعة الدورانية للمرزز Proptec rotary atomizer وهى ١٠٠٠ ك/و(-م/ث) والتى قد أعطت أقل نسب فى فواقد المواد البيولوجية مقارنة بغيرها من السرعات. و انه عند السرعة المنخفضة للمرزز الدورانى يمكن استعماله إلا انه يجب تعديل المرزز الدورانى لكى ينتج كمية كبيرة من الهواء والتي تساعد فى حمل المواد البيولوجية إلى النباتات و هذا ما تم عمله و عرضه فى بحث أخر.

إلا أن النظم الهيدروليكية للرش الأخرى المستعملة فى البحث قد أعطت اقل نسب في فواقد المواد البيولوجية مقارنة بالمرززProptec rotary atomizer .

كما أن المرززات External mixing twin fluid nozzles التى تم تطويرها تعد منافس قوى لاستخدامها فى المكافحة الحيوية إذ أنها لا تطلب طاقة كبيرة عند تشغيلها كما أنها تعمل تحت ضغط للسائل اقل من الضغط الجوى وهذا ما يؤهلها للاستخدام واسع المدى فى رش معظم المواد البيولوجية التى تحتاج إلى ضغوط منخفضة و الذى يكون من الصعوبة بمكان توفيره فى معظم آلات الرش التقليدية.