DMDS: a new alternative for soil disinfestation

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Abstract

For three years ATOFINA has been developing DMDS (one of the most important compound of *Allium*, a natural fumigant) for soil disinfestation in shank and drip applications (pure product and 95% Emulsifiable Concentrate). This compound has a zero Ozone Depletion Potential (ODP) and has a favourable toxicological and eco-toxicological profile.
The results from previous and current studies show that DMDS is a broad spectrum fumigant that has nematicide, fungicide, insecticide and herbicide effect.
Since 2002 several studies have been conducted in order to develop tools for the measurement of gas concentrations in the soil and to determine the influence of several covering systems on DMDS gas concentrations. Experimental trials were carried out in order to evaluate in open fields the effect of fumigation on the survival of selected fungi through bio-essays of bags containing several pathogens buried in the soil and to confirm in containers the nematicide effect using artificial infestation.
Based on the data presented DMDS could be a viable replacement for methyl bromide and other fumigants.

Keywords

DMDS, soil disinfestation, concentration time product, soil-borne fungi, nematodes.

Introduction

For three years ATOFINA has been developing DMDS (one of the most important compound of *Allium*, a natural fumigant) for soil disinfestation in shank and drip applications (pure product and 95% Emulsifiable Concentrate). This compound has a zero Ozone Depletion Potential (ODP) and has a favourable toxicological and eco-toxicological profile.
The results from previous and current studies show that DMDS is a broad spectrum fumigant that has nematicide, fungicide, insecticide and herbicide effect.
DMDS exerts a complex mode of action through mitochondria dysfunction and activation of ATP sensitive potassium channels and it has a powerful inhibition of the cytochrome oxydase (Auger et al., 2002).
DMDS was tested under laboratory conditions and was described as a promising soil fumigant according the first conclusions:
- Fungicide effects showed in terms of lethal concentration time products that a rate of 3249 $g.h/m^3$ can destroy 90% of resistant form of four soil-borne pathogens (*Sclerotinia sclerotiorum, Sclerotium rolfsii, Rhizoctonia solani* and *Phytophthora cactorum),*
- DMDS diffuses quickly through a depth of 33 cm of sandy loamy soil in soil columns, followed by homogeneous gas concentrations after 24 hours (Fritsch et al., 2002).
In this paper the results of studies conducted since 2002 are reported:
- The development of tools for the measurement of gas concentrations in fields and the determination of the influence of several covering systems on DMDS gas concentrations,
- The evaluation in fields of the effect of fumigation on the survival of selected fungi through bio-essays of bags containing several pathogens buried in the soil,
- The assessment in containers of the nematicide effect using artificial infestation.

1) Measurement of gas concentrations in fields

1-1 Materials and methods

Concerning DMDS it is possible to obtain a good response with a Thermal Conductivity Detector (TCD) and to calculate Concentration Time Product (CTP in g.h/m^3) in the soil using the Fumiscope or Gow Mac already used for methyl bromide.
Three experimental trials were carried out in 2002 and 2003 in France (Plant Protection Department) in open fields and greenhouses on loamy sandy soil and sandy soil.
DMDS was applied by soil injection or by drip irrigation using respectively pure product or 95% EC with different irrigation water amounts, ranging from 6 to 12 millimetres (mm) at application rates from 300 to 800 kg/ha (265 to 700 lbs/acre).
The trials 1 and 2 were conducted with 4 replicates and the standard product methyl bromide was applied with an equipment using cold injection (trial 1) and by soil injection (trial 2) at the registered dose of 500 kg/ha (440 lbs/ac). Virtually Impermeable Films (VIF) were used in all application including untreated control.
Concerning the trial 3 one treatment was not tarped; the second treatment was tarped with Low Density Polyethylene film (LDPE) and the third with VIF.

1-2 Results

DMDS gas concentrations were measured during 8 days (minimum 6 measures) in order to calculate the CTP in g/h/m^3 at 15 centimetres (cm) and 30 cm depth.
The results are reported in table 1 and table 2.

Table 1: CTP results (trials n° 1 and n° 2)

	Trial n° 1		**Trial n° 2**	
	15 cm	**30 cm**	**15 cm**	**30 cm**
MB 500 kg/ha+VIF (440lbs/ac)		6669		3085
DMDS injected 300 kg/ha+VIF (265lbs/ac)	3794 (b)	4503 (b)		
DMDS injected 600 kg/ha+VIF (530lbs/ac)	3920 (b)	4750 (ab)		
DMDS injected 800 kg/ha+VIF (700lbs/ac)	6548 (a)	6666 (a)	5675 (ab)	7783 (a)
DMDS in drip (6 mm) 800 kg/ha+VIF			6415 (ab)	2981 (b)
DMDS in drip (12 mm) 800 kg/ha+VIF			5902 (ab)	3821 (b)

Table 2: Increase of CTPs using LDPE films and VIF compared to no tarped (trial n° 3)

	Trial n° 3
DMDS injected 800 k/ha + LDPE (700lbs/ac)	+ 18%
DMDS injected 800 k/ha + VIF (700lbs/ac)	+ 110 %

1-3 Discussion

DMDS applied by injection and in drip system diffuses quickly in the soil.
By injection there is no significant difference between 15 cm and 30 cm depth.
In drip application the CTP seems to be higher at 15 cm depth and there is no significant difference using 6 and 12 mm irrigation water amount.
The CTP obtained is higher using VIF compared to no tarped or using LDPE films.

2) Evaluation of the fungicide effectiveness of DMDS

2-1 Materials and methods

Three experimental trials were carried out in 2002 and 2003 in France (Plant Protection Department) and in Italy (Di Va PRA) in order to evaluate the efficacy of DMDS on

Verticillium dalhiae, Sclerotinia sclerotiorum, Rhizoctonia solani, Sclerotium rolfsii and *Fusarium (Fusarium oxysporum lycopersici, Fusarium oxysporum radicis lycopersici, Fusarium oxysporum melonis*) through bio-essays.
The resistant forms of each pathogen were placed separately into small gas permeable tissue bags and buried in the soil at 10/15 and 20/30 cm depth before the fumigation.
The bags were taken out of the soil 7 days after fumigation and transferred to laboratories in order to evaluate the % of viability for each pathogen.

DMDS was applied by soil injection using pure product or by drip irrigation using 95% EC with different irrigation water amounts, ranging from 17 to 35 mm. at application rates from 300 to 800 l/ha (265 to 700 lbs/acre).
The reference product methyl bromide was applied with equipment used for cold injection or by soil injection at the registered dose of 400 to 500 kg/ha (350 to 440 lbs/ac). Virtually impermeable films were used in all applications including untreated control.

2-2 Results
DMDS control the soil borne fungi tested without any significant difference compared to MB at the following rates as indicated in the table 3.

Table 3: the effect of DMDS on soil borne fungi

Treatments	Location	Soil borne fungi
DMDS injected 300 kg/ha + VIF (265 lbs/ac) DMDS in drip system (37 mm) 300 kg/ha + VIF	Montesquieu (France) Albenga (Italy)	*Verticillium dalhiae* *Sclerotinia sclerotiorum*
DMDS injected 600 kg/ha + VIF (530 lbs/ac) DMDS in drip system (17 mm) 600 kg/ha + VIF	Montesquieu (France) Sicily (Italy)	*Rhizoctonia solani* *Fusarium (FOL-FORL-FOM)*
DMDS injected 800 kg/ha + VIF (700 lbs/ac)	Montesquieu (France)	*Sclerotium rolfsii*

2-3 Discussion
DMDS seems to be effective on major soil borne fungi at the rates from 300 to 800 kg/ha (265 to 7 00 lbs/ac) under VIF.

3) Evaluation of the nematicide effectiveness of DMDS

3-1 Materials and methods
The experiments were carried out in 2002 in laboratory and greenhouse in Leuven University (Belgium). After dilution in water (20% concentration) DMDS was applied into 25 litres buckets (at the rates from 1.5 to 9 ml per 25 l) containing 10 litres of infested soil with nematodes collected from the greenhouse. The sealed buckets were opened 4 days later and left open for 24 hours. After the soil was transferred into pots and plants were sowed or transplanted.
The following nematodes were evaluated:
-Root knot nematodes: *Meloïdogyne Incognita* and *Javanica* (control by transplanting tomatoes)
-Cyst nematodes: *Heterodera Schachtii* (control by sowing sugar beets).

3-2 Results

The results of the following assessments are reported in table 4:
- GSI (Gall Severity Index according to the scale of 0-5) and number of juveniles in 100 g soil for the control of *Meloïdogyne* on tomatoes
- Number of cyst per 100 g soil for the control of *Heterodera* on sugar beet.

Table 4: the effect of DMDS on root knot nematodes and cyst nematodes

	Meloïdogyne incognita		***Meloïdogyne Javanica***		***Heterodera Schachtii***
	GSI (0-5)	**Number of juveniles in 100 g soil**	**GSI (0-5)**	**Number of juveniles in 100 g soil**	**Number of Cysts per 100 g soil**
Untreated	4.3 (c)	1596 (c)	4.1 (c)	1080 (c)	609 (c)
DMDS 1.5 ml	3.2 (b)	317 (b)	3.0 (b)	413 (b)	413 (b)
DMDS 3 ml	2.9 (b)	313 (b)	2.7 (b)	408 (b)	219 (b)
DMDS 6 ml	1.6 (a)	49 (a)	1.4 (a)	59 (a)	67 (a)
DMDS 9 ml	1.3 (a)	46 (a)	1.3 (a)	33 (a)	36 (a)

3-3 Discussion

The parameters studied show significant difference between DMDS 1.5 ml and 3 ml compared to DMDS 6 ml and 9 ml. It seems that the efficacy of DMDS is similar for *Meloïdogyne incognita* and *javanica* and *Heterodera Schachtii.*
The necessary dose of DMDS required for effective control on root knot nematodes and cyst nematodes seems to be 6 ml per 25 litres bucket, if extrapolated to field values gives around 300 Kg/ha (265 lbs/ac).

Conclusions

DMDS seems promising in shank and drip application.under VIF on fungi at the rate of 600 to 800 kg/ha (530 to 700 lbs/ac) and on nematodes at the rate of 300 kg/ha (265 lbs/ac).
DMDS is still under evaluation on weeds, bacteria and insects and the evaluation in association with chloropicrin is under progress.
Based on the data presented DMDS could be a viable replacement for methyl bromide and other fumigants.

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References

AUGER J.,THIBOUT E., (2002) “Substances soufrées des Allium et des Crucifères et leurs potentialités phytosanitaires” In Bio-pesticides d’origine végétale. T.DOC. Paris : 77-95
FRITCSH J., BAUDRY A., AUBERT T., (2002). “DMDS as a new potential alternative to methyl bromide for soil disinfestations” Proc. International conference on alternatives to methyl bromide. Seville 5-8 March: 321