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EFFECT OF WATER QUALITY ON EFFICACY OF FUNGICIDES IN CONTROLING ROSE RUST

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Abstract: Saprol 190 EC (triforine) and Rubigan 12 EC (fenarimol) diluted in 6 types of water were applied against rose rust *Phragmidium mucronatum* Cooke. No adjuvants were added to the emulsion except when the spray mix was made using water from Poznań prepared in 2 variants: with an addition of Citowett AL and without it. Independently on the plant protection product type, efficacy of fungicides diluted in well water from Szczepankowo, Kościan or Śmigiel was better than when they were diluted in water after reversed osmosis. However, no type of water exerted any significant effect on efficacy of the investigated fungicides independently on the year of studies, although, in 1999, a better biological activity was shown by Rubigan 12 EC diluted in water from Kościan and Poznań than when they were diluted in water after reversed osmosis. The fungicides were most effective after addition of Citowett AL, however, a visible effect of this adjuvant showing increased rose protection against rose rust was found only in 1998.

Key words: water quality, triforine, fenarimol, rose, *Phragmidium mucronatum* Cooke

INTRODUCTION

Effectiveness of some herbicides used in the form of water solution (e.g. glifosat; 2.4-D) depends on multivalent ions (most frequently Ca, Mg and Fe) and it decreases when content of these ions in water rises (Stahlman and Phillips 1979; Woźnica 1990). On the other hand, there is little information about the effect of water quality on efficacy of presently used plant protection products which form emulsion in combination with water. It is known that stability of emulsions of these preparations depends on multivalent cations occurring in water in the greatest amounts; usually they include Ca and Mg being mainly responsible for water hardness and this feature, in turn, is regarded as a parameter characterizing the usefulness of water for diluting plant protection products in a better way than salinity (Linder 1972). Depending on the optimization of chemical composition of a gi-

ven preparation, emulsion of plant protection products shows a diversified stability in a defined range of water hardness used for diluting. In the literature, there is no information regarding the effect of water quality on the biological activity of presently used fungicides. The objective of this work was to investigate the effectiveness of fungicides used in the form of emulsion against rose rust *Phragmidium mucronatum* Cooke depending on water type applied for their dilution.

MATERIAL AND METHODS

Experiments were carried out in the years 1997–1999 in a rose plantation in Krzesiny (Wielkopolska province). The experiments were established in a completely random design in 4 replications. On each plot measering 3 × 1.5 m, 30 rose shrubs were grown. The effect of 2 factors: I – water type, and II – fungicide type were investigated in the studies. Control variant consisted of plots untreated with fungicides.

Saprol 190 EC (triforine) (1.6 dm^3 ha^{-1}) and Rubigan 12 EC (fenarimol) (0.48 dm^3 ha^{-1}) were applied in the experiment.

In the studies, different types of well water were used originating from several sources, and conditioned water chemical composition of which (except distilled water) is shown in table 1. Well water originated from Szczepankowo and from Kościan (in 1998 and 1999) or from Śmigiel (only 1997). Conditioned water were: 1) municipal water from Poznań, 2) water from reversed osmosis, 3) distilled water, 4) water artificially hardened to 215.04 mval by addition to distilled water of

Table 1. Chemical composition of water used in field experiments – mean value from the years 1997–1999

Component (mg · dm^{-3}) or parameter	Type of water or place of its origin				
	Hardened	Kościan or Śmigiel	Szczepankowo	Poznań	Reversed osmosis
$N\text{-}NH_4$	–	0.175	trace	0.004	trace
$N\text{-}NO_3$	–	54.55	1.28	0.31	0.68
P	–	1.448	0.860	0.043	0.117
K	–	31.18	2.97	4.2	0.18
Ca	439.15	153.75	30.1	113.6	6.29
Mg	109.6	44.63	29.20	11.76	0.81
Na	–	66.62	82.20	21.07	0.33
Cl	–	69.47	24.37	40.5	0.4
$S\text{-}SO_4$	–	69.83	3.3	97.93	0.3
HCO_3- (mval · dm^{-3})	–	4.658	7.9	3.99	0.8
pH	–	6.90	7.00	7.42	6.67
EC	–	2.205	0.718	No date	0.063
Fe	–	0.054	0.328	0.097	0.009
Mn	–	0.019	0.051	0.02	0.004
Zn	–	0.298	0.764	0.087	0.060
Cu	–	trace	trace	0.002	trace
B	–	0.078	0.02	No date	0.002
Hardness Ca+Mg (mval · dm^{-3})	215.04	89.01	30.63	52.02	3

calcium chloride analytically pure (1.216 $g \cdot dm^{-3}$) and magnesium chloride analytically pure (0.692 $g \cdot dm^{-3}$).

From the end of July until mid-September, roses were sprayed with spraying mixture of volume: 1600, 800, 400 or 200 $dm^{3} \cdot ha^{-1}$. Each year, 5 fungicide treatments were carried out in 7–14 week intervals. Spraying mixture was applied to the plants using a shoulder pressure-sprayer Kwazar Orion 6 equipped with a slit-atomizer Tee Jet XR 110-02 and a pressure regulator (Lurmark Co.) maintaining a constant liquid pressure of 0.2 Bar. Control of diseases (except for the period of experiments), weeds, pests and other agrotechnical treatments was carried out according to the respective recommendations in a homogenous way on the whole plantation.

The evaluation of rose infestation by rust was performed only once, 8–10 days after completing a series of treatments, on 50 leaves of each plot using a conventional 5-degree classification scale: 0 – no damage; 1 – up to 5 uredinia on the whole leaf; 2 – on the average 1–5 uredinia on one leaflet; 3 – on the average 6–20 uredinia on one leaflet; 4 – above 20 uredinia on one leaflet.

Statistical analysis of the experiments was carried out using Fisher F-test and Tukey's multiple test at significance level $P=0.05$. A synthesis of experiments of all the years was carried out as well using a mixed model in which the effect of years is a random factor.

RESULTS AND DISCUSSION

Fungicides applied in these studies differed significantly regarding their efficacy against rose rust (Tab. 2). Every year, Saprol 190 EC showed a higher efficacy than Rubigan 12 EC. The latter diluted in water after reversed osmosis was not effective at all in the years 1997 and 1999. In 1997, it showed no effect after diluting in well water and distilled water, either. Only Saprol 190 EC found application in the practical control of rose rust. Generally, tested fungicides were the least effective in 1997 when rose rust occurred in high intensity, while in 1998 (the least occurrence rate of rose rust), the effectiveness of the preparations was the highest (Tab. 2).

Independently on the year of studies, there was no significant effect of water type on the efficacy of Saprol 190 EC and Rubigan 12 EC (Tab. 2). In spite of the fact that such relation was found in the years 1999 and 1998, significant differences in results were recorded only in reference to the less efficacious preparation (Rubigan 12 EC). In 1999, Rubigan 12 EC was more effective after diluting in water from Kościan and from Poznań (with addition of Citowett AL or without it) than in water after reversed osmosis. On the other hand, in 1998, the same fungicide diluted in water from Poznań with addition of Citowett AL was significantly more effective than after diluting in the remaining water types except for the hardened water (Tab. 2). So, water type contributed only insignificantly to the effectiveness of the discussed fungicides, but this effect increased after addition of Citowett AL. In the control of rose mildew, a slightly better effect of Rubigan 12 EC was obtained with very hard water and with water from Szczepankowo, while Saprol 190 EC showed better results after dilution in distilled water and in water from Szczepankowo (Ratajkiewicz 2002). Laboratory studies also showed that stability of the emulsion of Saprol 190

Table 2. Effect of water type on effectiveness of Saprol 190 EC and Rubigan 12 EC in protection of rose plants against rust (*P. mucronatum*)

Water type	Disease rating			
	1997	1998	1999	Mean
Check	3.45	1.78	2.59	2.61
Saprol 190 EC				
Hardened	2.92	0.52c	0.97cd	1.47
Kościan or Śmigiel	3.01	0.31c	0.84d	1.39
Distilled	3.10	0.22c	0.82d	1.38
Reverse osmosis	2.76	0.21c	0.90d	1.29
Szczepankowo	3.03	0.14c	0.61d	1.26
Municipal from Poznań	3.18	0.25c	0.88d	1.44
Municipal from Poznań + Citowett AL	2.80	0.18c	0.39d	1.12
Mean	2.97B	0.26B	0.77B	1.34
Rubigan 12 EC				
Hardened	3.38	1.23ab	2.15ab	2.25
Kościan or Śmigiel	3.55	1.57a	1.42bc	2.18
Distilled	3.55	1.49a	2.17ab	2.40
Reverse osmosis	3.65	1.70a	2.91a	2.75
Szczepankowo	3.39	1.50a	2.01ab	2.30
Municipal from Poznań	3.28	1.57a	1.92b	2.26
Poznań + Citowett AL	2.97	0.67bc	1.90bc	1.85
Mean	3.40A	1.39A	2.07A	2.28

Letter marks of mean values are used only in case when any statistically significant differences were found. Mean values marked with the same letter do not differ significantly at p=0.05

EC and Rubigan 12EC depended on water hardness (Ratajkiewicz 2002). In field conditions, occurred flocculation followed by an intensive sedimentation. However, these phenomena that could have contributed indirectly to a lower effectiveness of the preparations (Wiśniewski and Doroz 1979) occurred only in emulsions of Saprol 190 EC prepared using two types of very hard water of a different origin (hardened and from Kościan or Śmigiel) and they led to a quick blocking of the sprayer filter.

On the basis of the available data, it is not possible to determinate what could be the reason of the worse effectiveness of Rubigan 12 EC diluted in water after reversed osmosis. Probably water hardness alone wasn't the cause, since softer distilled water gave better rose protection independent of the year of studies.

It seems that effectiveness of fungicides diluted in well water (from Szczepankowo, Kościan or Śmigiel) can be slightly better than with the use of conditioned water, however, this conclusion cannot be directly inferred from the result of statistical analysis. However, if it were true, then a slightly better efficacy of fungicides diluted in well water would be rather the effect of total chemical composition of water than of any single component or property. On the basis of chemical analysis, one can only point to the proportionally higher content of univalent ions in relation to multivalent ions in water from Szczepankowo when compared to the other water types. As mentioned earlier, a great amount of multivalent cations

sometimes deteriorates the effectiveness of some herbicides (Stahlman and Phillips 1979; Woźnica 1990). Worthy of attention is that a good biological effectiveness of fungicides diluted in water from Szczepankowo was obtained in spite of the fact that shortly after it had been taken from the well, due to the contact with atmospheric oxygen, appeared in it a rust-coloured sediment originating mainly from ferric oxide. Water from Szczepankowo contained significantly greater amount of iron than other types of water, however, the amount was too small to deteriorate effectiveness of the preparation, as it was observed in experiments with glifosat (Stahlman and Phillips 1979; Nalewaja and Matysiak 1991).

The highest positive results of rose protection against rust were obtained when Citowett AL was added to the emulsion prepared with the use of Poznań water, however only in 1998, effectiveness of this liquid was significantly better than without addition of the surfactant (only Rubigan 12 EC). Citowett AL also contributed to an essential increase of effectiveness of Saprol 190 EC and Rubigan 12 EC against rose powdery mildew (Ratajkiewicz 2002). Surfactants including Citowett AL decrease surface tension of liquid contributing thereby to a better wetting of plant surface and they have been used in the protection of rose against diseases at least for several previous decades (Alwin and Kubacki 1963).

CONCLUSIONS

1. Independently on the year of studies, water type used for diluting Rubigan 12 EC and Saprol 190 EC had no essential effect on effectiveness against rose rust.
2. Citowett AL increased effectiveness of fungicides against rose rust, and its addition to the liquid was of a greater importance than the selection of adequate water type for dilution.

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POLISH SUMMARY

WPŁYW JAKOŚCI WODY NA SKUTECZNOŚĆ DZIAŁANIA FUNGICYDÓW PRZECIWKO RDZY RÓŻY (*PHRAGMIDIUM MUCRONATUM* COOKE)

Saprol 190 EC (triforyna) i Rubigan 12 EC (fenarimol) rozcieńczano w 6 rodzajach wody i stosowano przeciwko rdzy róży *Phragmidium mucronatum* Cooke. Do cieczy użytkowej w formie emulsji nie dodawano adiuwantów. Jedynie ciecz roboczą sporządzoną z użyciem wody z Poznania przygotowano w 2 wariantach: z dodatkiem i bez dodatku preparatu Citowett AL. Wody studzienne (ze Szczepankowa i Kościana) okazały się lepszymi nośnikami obu fungicydów niż uzdatnione. Nie wykazano, żeby rodzaj wody wpływał istotnie na skuteczność działania któregoś z fungicydów niezależnie od roku badań, jakkolwiek w 1999 roku uzyskano lepszą aktywność biologiczną fungicydu Rubigan 12 EC rozcieńczonego w wodach z Kościana i Poznania niż z odwróconej osmozy. Dodatek adiuwanta Citowett AL wpływał korzystnie na skuteczność działania fungicydów przeciwko rdzy róży.